Beginner's Telescope: Test Report

ASTRONOMY®

May 1995 U.S. $3.50
U.K. £1.95
Can. $4.95

The Great Comet Crash: What *Really* Happened?

ICD 08070

Exploding Star

- What Lies at the Milky Way's Center?
- Hot New Film For Astrophotos

MEADE
12" LX200
10" LX200
8" LX200

Supplied complete per catalog specifications**:

8" LX200 Schmidt-Cassegrain	**$2495.**
10" LX200 Schmidt-Cassegrain	**$2895.**
12" LX200 Schmidt-Cassegrain	**$3995.**

Packing & shipping in 48 states: 8"—$105; 10"—$145; 12"—$215.

- **All prices shown are suggested USA mail-order retail prices, exclusive of sales taxes or credit card charges, if applicable.

- For dealer or catalog information see the **Meade Starfinder Reflecting Telescope** ad in this issue.

Now with *one arc-minute* pointing accuracy and 64,350-object onboard database as *standard-equipment!*

Meade 8", 10", and 12" LX200 models with standard-equipment High-Precision Pointing™ software now automatically GO TO any input RA and Dec, or to any object in the 64,350-object database, to a pointing precision within one arc-minute!

New Meade Version 3.30 software and high-resolution encoders, used in conjunction with the unique Meade SYNC command, now yield the most precise automatic slewing ever offered in a commercial telescope, an observatory-level of precision and *more than 5 times the precision obtainable with any competing computer-controlled telescope.* Data entry through the telescope's keypad hand controller may be made either from the onboard 64,350-object library database *(see description at right)* or by inputting the desired object's RA and Dec.

Such precise object-acquisition, selectable during either altazimuth or equatorial operation of the LX200, has numerous important implications for the serious observer:

HIGH PRECISION POINTING

LX200's with High-Precision Pointing have a logo-plate affixed to the telescope's drive base.

All Meade LX200 models now include a 64,350-object onboard database as standard equipment.

Imagine having 64,350 celestial objects at the tip of your finger: 64,350 objects that you can center in the telescopic field just by entering and pressing GO TO on the hand controller. **More than 6 times the size of object libraries included with competing telescopes,** the Meade 64,350-object library includes an incredible array of phenomena—virtually a lifetime of deep-space study, even for the advanced observer:

12,921	galaxies from the Uppsala General Catalog; the complete UGC catalog.
7,840	objects from the New General Catalog; the complete NGC catalog.
5,386	objects from the Index Catalog; the complete IC catalog.
21,815	variable stars; the complete listing from the General Catalog of Variable Stars.
15,928	stars from the Smithsonian Astrophysical Observatory (SAO) catalog of stars brighter than 7th magnitude.
351	alignment stars for the LX200 telescope.
110	Messier objects; the complete listing.
8	major planets from Mercury to Pluto.
64,359	objects, total

LX200
SCHMIDT-CASSEGRAINS

☐ Use the GO TO command to *find and center an object in the field of a 4mm eyepiece.*

☐ With other telescopes, acquiring even bright objects on the chip of a CCD imager is generally a chore at best, searching and slewing by trial-and-error until at last the object is positioned on the chip. The LX200's High-Precision Pointing places *every* object on *every* CCD chip *every* time.

☐ Suppose you wish to CCD-image a supernova in an 18th magnitude galaxy—a galaxy invisible *except* through the process of CCD imaging. With Meade High-Precision Pointing, the galaxy can be placed on the chip of every commercially-available CCD unit.

☐ Photographing or imaging faint objects such as the planet Pluto, or comets and asteroids near the photographic limit of the telescope, and plotting the motion of these objects night-to-night, now becomes practical, since the photograph or image may be taken *without the observer ever having seen the object visually,* but knowing that the LX200 will place the object precisely in the telescopic field.

SPECIFICATIONS: 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel display on the drive base; manual and electric slow-motion controls on both axes; keypad handheld controller with digital readout display, permanently programmable Smart Drive™, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,350-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC (for field operation from any 12v. auto cigarette lighter plug, use the Meade #1812 Electronic DC Adapter, a 4-oz. unit available optionally); 8 x 50mm viewfinder with crosshairs; 1.25" diagonal prism (8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (8", 10") or giant field tripod (12"); foam-fitted carrying case; complete operating instructions.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
World's Leading Manufacturer of Astronomical Telescopes for the Serious Amateur
16542 Millikan Avenue, Irvine, Calif. 92714 ☐ (714) 756-2291
FAX: (714) 756-1450

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Lund Observatory

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ON THE COVER

EXPLODING STARS leave debris like the Crab Nebula (shown here), debris that seeds the Galaxy with material for new stars. Stars at the center of the Galaxy, however, suffer a different fate: A massive black hole shreds them like paper, reducing them to atoms (see story on page 32). Image by Klaus Meisenheimer, Calar Alto Observatory; image processing by Axel M. Quetz.

ASTRONOMY: Phil Kirchmeier

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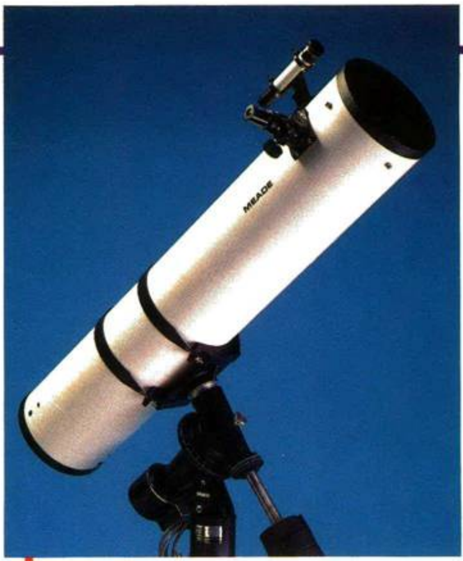
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BEHIND THE SCENES

You, too, Can Be a Winner

Confession: We don't notify you by uniformed messenger when we make the award. Nor do we send you a telegram. And I can positively, absolutely guarantee that you will not find Ed McMahon in your front yard with a film crew. Still, if you're the lucky one, I think you'll feel pretty good anyway.

What am I talking about? Why, the Best Astrophoto Award, of course — the $100 prize we give away each month for the best astrophoto received. The award not only nets you a cash award, but also gets prominent display just inside the back cover, as the "Ultimate Exposure" in Reader Reports.

Each month, hundreds of envelopes arrive packed with photos at ASTRONOMY's offices. We examine each carefully and choose those we think are the best. It may be that the photo captures a unique event or depicts an unusual object — or perhaps it just has a special quality that makes it outstanding.

ASTRONOMY: Chris Becker

Looking for the winner: Photo Editor Dave Eicher

Unfortunately, we can use immediately only a tiny fraction of what we receive, but we often set aside high-quality images for later use. This is why we ask that you send us only those photos we can hang onto indefinitely. Many photos see print months or even years after being submitted.

Please, also put your name and address on each photo you send. I know that's a bother when you're submitting 43 slides, but we don't want your photos mixed up with anyone else's. We're extremely careful in handling them, but accidents can happen.

Last, if you include your Social Security number along with all the technical info you put into your letter (that's what's called a broad hint), it's easier to pay you. How much? We pay $25 for each photo we use in the magazine, $100 for the monthly winner, and $150 if it's good enough for the cover.

May the best astrophotos win!

Sincerely,

Robert Burnham

Robert Burnham
Editor

P.S. For all you electronic imagers: Although we run Adobe Photoshop 2.5 on a Mac IIci, we can use IBM disks just fine. We prefer images saved in TIFF or PICT formats, and can handle JPEG files and various camera formats.

LETTERS

Two by Two on Earth?

I enjoyed the article "Two by Two They Came" by Dan Durda (January 1995) about paired asteroids and the resulting impact sites on planets. For years I have puzzled over the origin of two craters here in Oregon (whimsically named "Big Hole" and "Hole-in-the-Ground"). Locals claim the craters are supposedly of volcanic origin, but a few facts argue against that, at least potentially. They are roughly circular, each have about the same diameter (about one mile), are approximately the same depth (about 300 feet), and are separated by 5.8 miles.

Long ago, when the craters were discovered, it would have been ludicrous to propose an impact as their origin. But could two small asteroids, each about 150 feet in diameter and orbiting each other, have caused these craters? — *Paul Lutus, Ashland, Oregon*

Hey NASA, uh . . . Beam Me Up

Eric Chaisson's article "NASA's Needed Vision" (January 1995) struck a chord with me. Although NASA is responsible for selling the necessity of missions to the public, the agency can't be blamed for the public's lack of interest in space science and exploration. The problem is that most people's concept of what space exploration is comes from anticipating who will next fall in love with Captain James Tiberius Kirk on *Star Trek*. With such a skewed view of what we stand to gain from exploring space, it's no wonder the public has put NASA's future into a questionable position. — *Christopher L. Spears, Olathe, Kansas*

What we need is a global consensus on space exploration and cooperation between nations. Perhaps one day NASA will be remembered as the pioneering nucleus of what became Earth's global space exploration organization. — *Anthony M. Giovia, Livingston, New Jersey*

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The Audit Bureau

MEADE

EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types for 1994, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm each: **$87.95** (3.45)

32mm (52°); **40mm** (44°) each: **109.95** (3.79)

56mm (52°; 2") **229.95** (5.48)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

F/6.3 FOCAL REDUCER/FIELD

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

SALE!

Series 3000 Plössls Save up to 30%!

Now you can buy Meade *multi-coated* Series 3000 Plössl Eyepieces—the finest moderately-priced eyepieces ever manufactured—at never-before prices!

See complete eyepiece description elsewhere on this page.

Buy one or buy a dozen!
No minimum, no maximum!

Series 3000 Plössl 5, 6.7, 9.5, 16, or 25mm:

each **$39.95** (3.45)

(regularly $46.95 to $57.95)

Series 3000 Plössl 40mm:

each **$69.95** (3.79)

(regularly $79.95)

This special offer is valid between November 20, 1994 and May 31, 1995, at participating Meade dealers in the U.S.A. and is subject to eyepiece availability.

Series 4000™ Super Wide Angle

For exquisite wide-angle images at low-to-medium powers, ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8, 18, and 24.5mm are superb complements to the #140 Barlow.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $159.95** (3.49); **18mm: 169.95** (3.69); **24.5mm: 199.95** (3.89); **32mm** (2"): **279.95** (4.78); **40mm** (2"): **339.95** (5.48)

Series 4000™ Ultra Wide Angle

The ultimate eyepieces; extreme image sharpness over an amazing 84° field.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)–**4.7mm: $179.95** (3.29); **6.7mm: 219.95** (3.29); **8.8mm** (1.25"/2"): **269.95** (4.78); **14mm** (1.25"/2"): **329.95** (5.48)

Series 4000™ #140 2x Apochromatic Barlow Lens

The most advanced Barlow Lens available for commercial telescopes; includes 3-element, air-spaced optics, multi-coated. Unmatched in image resolution, contrast and color correction. Accepts 1.25" eyepieces. Lens dia. 28mm; clear aperture 26mm.

$79.95 (3.29)

Series 3000™ Plössls

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce excellent results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$57.95** (3.45) **Any 2: $52.95** each; **Any 3: $48.95** each; **Any 4 or 5: $46.95** each.

Series 3000™ Plössl 40mm

A perfect complement to the Series 3000 Plössls at left, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, multi-coated. Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

Series 4000 Photo-Visual Color Filters (1.25")—Made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

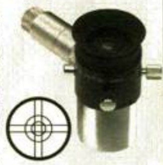
	each **$14.95** (2.29)
Moon Filter #ND96–Reduces brightness by 87%.	**16.95** (2.29)
Set #1–4 filters: #12, #23A, #58, #80A	**54.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**54.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**54.95** (2.98)
Sets #1 & #2–8 filters	**99.95** (3.45)
Sets #1, #2, & #3–12 filters	**144.95** (3.79)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (2.98)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.29)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.29)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (2.98)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.29)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.29)

World's Most Advanced Illuminated Reticle Eyepiece



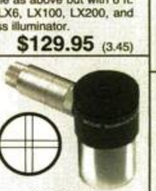
Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. **Internal batteries included.** Multi-coated optics. Bullseye reticle. 1.25"

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

MA 12mm Illuminated Reticle Eyepiece



Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. **Batteries included.**

$99.95 (3.45)

MA 12mm—Same as above but with cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **$99.95** (3.79)

Camera Adapters (1.25" & .965")

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95 (2.98) **1.25": $29.95** (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

Tele-Extenders

TELE-EXTENDER

For Eyepiece-Projection photography with any Meade or Celestron SCT. Threads on to any eyepiece-holder. Use with T-mount for your camera.

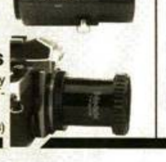
Basic Tele-Extender: *(above)* Fixed projection power; use with eyepiece for lunar and planetary photos.

$29.95 (2.98)

Variable Tele-Extender: Sliding cell, with lock, permits wide range of projection magnifications with the same eyepiece.

$39.95 (2.98)

T-Adapters for SCT's



For Prime Focus photography with any Meade or Celestron SCT. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25"

$59.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

Modified Achromatic Eyepieces

An improvement on the traditional Kellner design, these 3-element Modified Achromatic eyepieces give sharp, faithful, well-corrected images of the moon, planets, and deep-space at an economical price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (2.98)

HOW TO ORDER

■ Prices shown are suggested USA mail-order retail prices and do not include any applicable sales taxes.

■ Suggested shipping and handling charges to the 48 states by UPS or US Mail shown in ( ) next to each price.

■ Meade accessories may be ordered from any Meade Advanced Products Dealer. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

CALIFORNIA TELESCOPE CO., Burbank, CA.
Orders: 800-843-4780; Info.: 818-505-8424.

CITY CAMERA, Dearborn, MI.
Orders: 800-359-5085; Info.: 313-846-3922.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 510-447-9570.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders: 800-621-2248; Info/IL: 312-332-2000.

Canada:
KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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MEADE

STARFINDER™ DOBSONIANS

Now you can buy a Dobsonian telescope with quality Meade® optics and components—at a fraction of the price you'd expect to pay.

And receive a $125 Accessory Package for only $49.95!

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STARFINDER
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MEADE
FINDER
EADE

10" f/4.5
$595.

12.5" f/4.8
$795.

8" f/6
$425.

Shown with optional #637 6 x 30mm or #545 8 x 50mm Viewfinders

6" f/8
$325.

SPECIAL ACCESSORY OFFER!

At the time you order any Starfinder 6", 8", 10", 12.5", or 16" Dobsonian Telescope, you can buy **two additional Meade multi-coated Modified Achromatic MA9mm and 12mm eyepieces *and* the Meade #637 6 x 30mm coated achromatic viewfinder with metal bracket for a *total* of only $49.95! Purchased separately, the 2 additional eyepieces and viewfinder sell for $125.85!** *(Shown in photo: MA9mm, MA12mm, and standard-equipment MA25mm eyepieces, with #637 6 x 30mm viewfinder.)* Offer valid until further notice.

Starfinder Dobsonian 16

16" f/4.5
$1195.

MEADE
STARFINDER
MEADE

See the Meade General Catalog for details.

Includes giant #682 focuser; shown with optional 8 x 50mm viewfinder.

Compare Meade Starfinders *feature-for-feature* with other similarly priced Dobsonians!

■ **Primary and Secondary Mirrors of Low-Expansion Pyrex® glass!** Unlike the plate-glass optics of other Dobsonians that can become thermally unstable (especially in larger apertures), Meade Dobsonians include the *exact same* professional-quality Grade-A, fine-annealed Pyrex® optical systems used on Meade Starfinder Equatorial Reflectors. Optics that meet the theoretical limits of resolution for their apertures.

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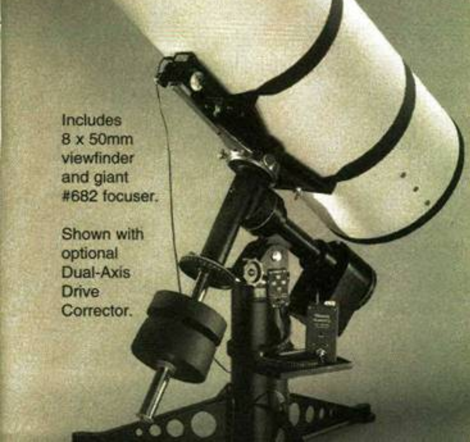

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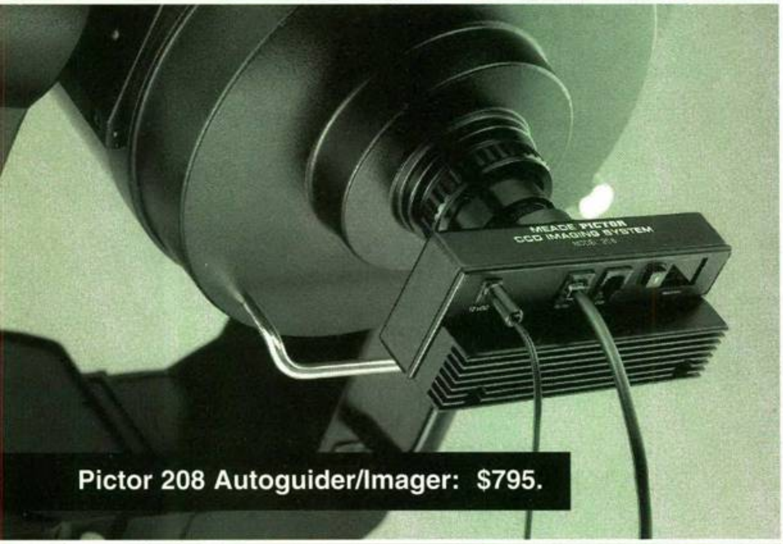
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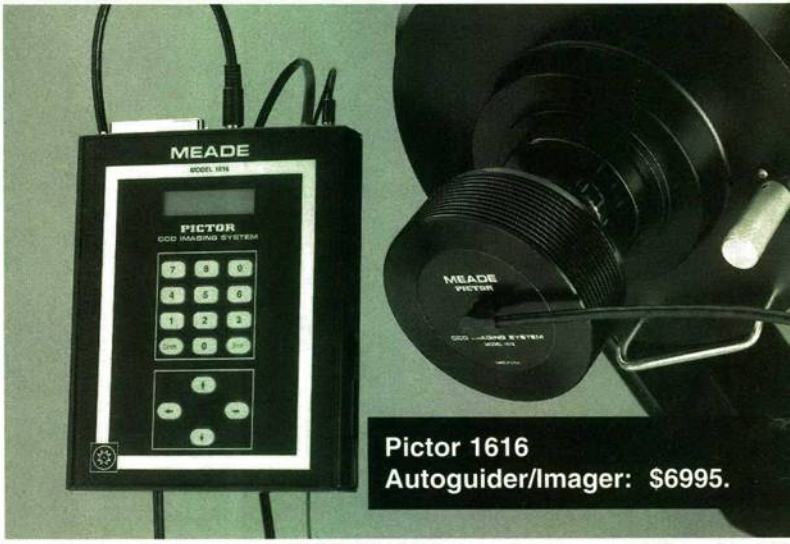
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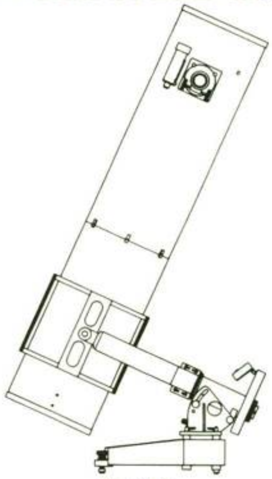

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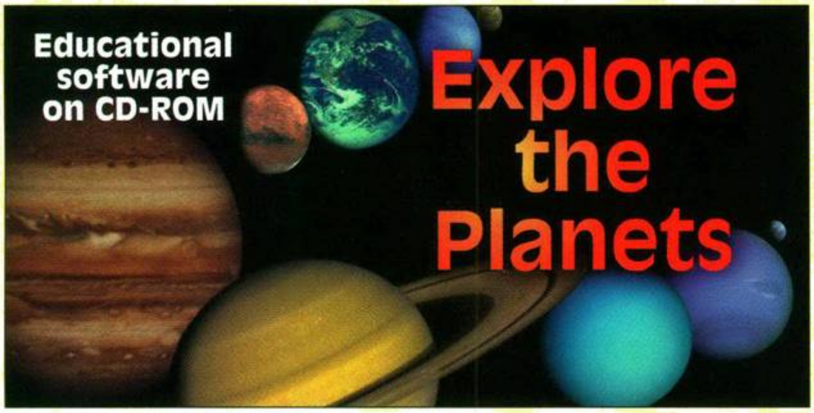

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LETTERS

When Did the Galaxies Debut?

In "The Debut of Galaxies" (December 1994), Ron Cowen states that light from some quasars took 13 billion years to reach us. Yet the article also says that the universe is 15 billion years old. If both statements are true, wouldn't the universe have been just 2 billion years old when the quasar light started toward us? How could the quasars have been 13 billion light-years away from us when the universe was only 2 billion years old? — *Steve Pemberton, Orange, California*

Thanks for the great story — pieces like that are the main reason I subscribe to ASTRONOMY. However, it seems that Cowen contradicts another article, "Candles to Light the Night" by David J. Eicher (September 1994). Eicher surveyed the range of methods to measure distance in the universe, and according to him the age of the universe is between 8 billion and 15 billion years. Yet Cowen writes about the age of the universe as if it were known to be 15 billion years. Where did this number come from, or was the value of the Hubble constant determined sometime since September? — *Yury Voloshin, Brooklyn, New York*

— The quasars were only 2 billion years old when they emitted the light. The universe continues to expand, so the 13 billion light-years refers to the present distance between Earth and the quasar, not the distance 13 billion years ago. "Everything You Wanted to Know About the Big Bang," by Richard Talcott, January 1994, may help explain this look-back time problem.

The distance scale and age of the universe are still very much in question. However, research announced in the autumn of 1994 by Wendy Freedman and a team of collaborators suggests the age of the universe may be on the relatively young side. Freedman used the Hubble Space Telescope to gauge the distance to Virgo and by implication the universe's age. For more information, see "How Far to Virgo?" by Ken Croswell, March 1995.

Color Me Pluto

Among the fine articles in the January 1995 issue, the AstroNews story about Pluto (p. 28) was especially interesting. During a break from variable star observing with my 12.5-inch reflector on April 27-28, 1989, I looked at Pluto for just the fourth time. The planet was some 45° above the horizon. At 250x Pluto appeared fairly bright and distinctly

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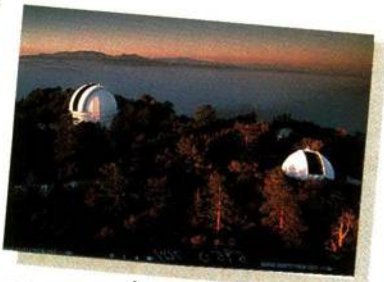

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tawny or brownish yellow. The illustration in your article seemed to match this color. But how could I see any hue in a magnitude 13.7 object?

How do other visual observers see Pluto with telescopes of 10 inches or larger aperture? — *Philip C. Steffey, Daytona Beach, Florida*

Deep-Sky Observers, Unite!

Readers of ASTRONOMY who enjoy observing star clusters, nebulae, and galaxies might not be aware of a group devoted solely to deep-sky observers and photographers. The National Deep Sky Observers Society was founded in 1976 with two goals in mind: to serve as a clearinghouse for observations and to encourage communication between observers with similar interests. Our journal, Betelgeuse, has been published since August 1976.

The society caters to novices and advanced amateurs, accepting and publishing observations of everything from the Milky Way to the most obscure nebulae and distant galaxies. Membership in the organization costs $20 per year, which includes *Betelgeuse* and *The Practical Observer*, both quarterly publications. For more information, send a 32-cent stamp. — *Alan Goldstein, National Coordinator, NDSOS, 1607 Washington Blvd., Louisville, Kentucky 40242.*

Return of the Glass Pushers

I enjoyed "Build Your Own 10-inch Portascope" by David Bruning (January 1995). The article was especially interesting because my club, the Springfield Telescope Makers, held a telescope-making demonstration at last summer's Stellafane convention in Springfield, Vermont. We were amazed at the enthusiastic response from the crowd when it came to grinding one's own mirror. Because of this, I would like to take issue with the suggestion that readers might want to "purchase hard to build parts such as the diagonal mirror, diagonal mirror holder, and primary mirror" rather than make them.

It's surprising how many people are interested in grinding their own optics. A nice follow-up on this project might be a step-by-step guide to grinding a mirror. — *Thomas J. Spirock, Belleville, New Jersey*

Theft Alert

An unfortunate incident occurred last year at the Connecticut Star Party, the theft of an eyepiece. This has happened a few times in the past at the Texas Star Party and Astro Assembly, among other places. This needs to be brought to the attention of everyone who attends public star parties. Such thefts are becoming more common. Could ASTRONOMY publish information on equipment stolen at star parties? This would help by making readers more aware of such problems and may help victims actually locate or recover items. — *Al Washburn, president, The Astronomical Society of New Haven, Inc., New Haven, Connecticut*

— We will publish alerts describing material stolen at star parties in this column as we receive them.

North American Sundial Society

A group of interested amateurs has recently formed the North American Sundial Society. The focus of the society is on sundials as scientific instruments and as historical and architectural artifacts. Forgotten by many, sundials continue to be of interest. The society publishes a quarterly journal in paper and electronic form and will hold an annual conference. For more information, write me. — *Allan D. Pratt, NASS Membership Chair, 1936 East Belmont Drive, Tempe, AZ 85284*

Photos vs. CCDs

While the argument rages on in your letters column over whether traditional photographic film or CCD cameras are better for recording stars, let us not lose sight of the contributions made by both methods.

Photographs have brought us such discoveries as near-light-speed jets, a multitude of comets and asteroids, and thousands of distant galaxies, but it took CCD imaging to show us that ancient philosophers and theologians were wrong. Stars are neither perfect spheres nor flattened orbs. CCDs have shown us that stars are squares. — *Jim Whitehouse, Hudson, Michigan*

Five Degrees of Separation

In the past few months I have been surprised that no one made a big deal about Venus' being so close to the Sun during the November 3, 1994, eclipse. During totality Venus and the Sun/Moon were separated by a mere 5°. They hadn't been so close during a solar eclipse since July 18, 1860.

I watched the eclipse from Bolivia and when totality began I immediately started screaming "Look at Venus!" It was beautiful, and seeing the pair formed by Venus and the Sun/Moon

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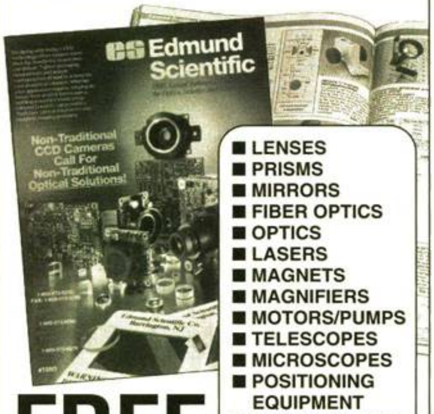
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LETTERS

stunned me as much as my first solar eclipse did 15 years ago. — *Raymond Brooks, Round Lake Beach, Illinois*

Here Come the Kuiperoids

I've enjoyed the several recent articles you've published covering the increasing number of objects being discovered in the outer solar system. Planetary scientist Alan Stern is quite right when he says that these so-called Kuiper Belt objects are new kinds of objects, and we are struggling to label them as asteroids, comets, ice dwarfs, or planets. Perhaps we need a new designation such as Kuiperoids for these distant members of the solar system. — *John Norris, Pasadena, Texas*

High-Tech Gear Necessary?

I've enjoyed following the lukewarm debate over whether amateurs should own a range of expensive, high-tech equipment or simply pursue their enjoyment of the sky with a small telescope and an affordable eyepiece. I'm in the latter camp.

Thousands of us out here are still toting our faithful 6-inch homemade scopes and will never be able to afford a big, brand-new instrument. We are still out at night in balmy or freezing weather checking out our favorite objects. Why not enjoy that 6-inch scope and help others, especially children, learn the sky? There's a lot you can do with your 6-inch reflector. — *Karena Burk, Creswick, Victoria, Australia*

There's a certain satisfaction from both finding and seeing some of the more obscure and dim objects in the night sky. The real shame affecting our hobby is not the race for more aperture but the use of unshielded outdoor lighting. Rather than belittling those of us who own large scopes, why not put some of that energy into helping the fight against light pollution? — *Jack Warwick, Charlotte, North Carolina*

Correction

The last sentence of "How Far to Virgo" (March 1995) was attributed to Wendy Freedman rather than author Ken Croswell. Our apologies. ☐

ASTRONOMY welcomes feedback. Send your letter to ASTRONOMY Letters, P.O. Box 1612, Waukesha, Wi 53187-1612, or on the Internet, use 72000.2704@CompuServe.com. Letters may be edited for length and clarity.

The Care and Feeding of Black Holes

by Walter C. Driedger

Gravitational attraction
(Always mutually shared)
Is the product of the masses
Over distance squared.

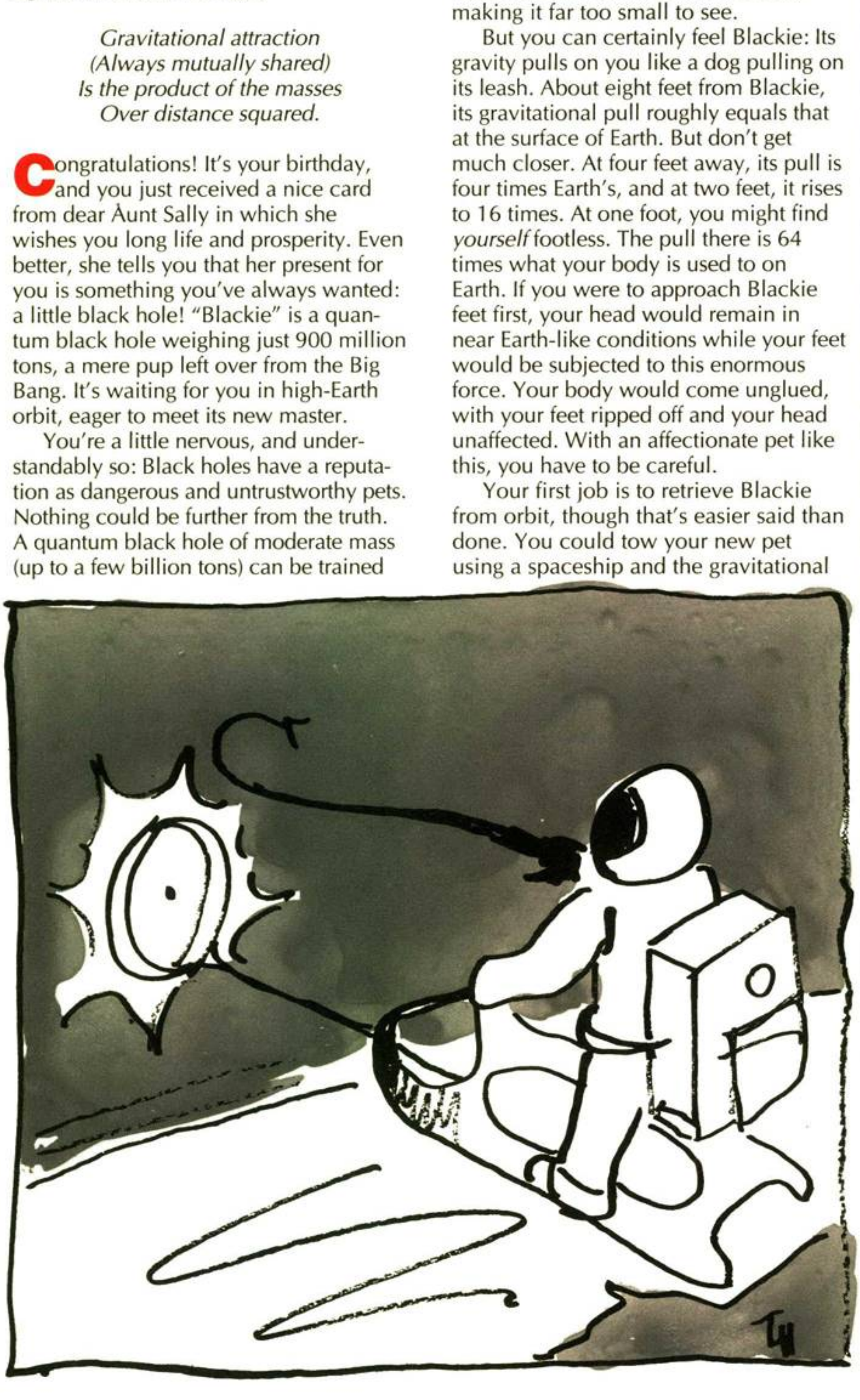
Congratulations! It's your birthday, and you just received a nice card from dear Aunt Sally in which she wishes you long life and prosperity. Even better, she tells you that her present for you is something you've always wanted: a little black hole! "Blackie" is a quantum black hole weighing just 900 million tons, a mere pup left over from the Big Bang. It's waiting for you in high-Earth orbit, eager to meet its new master.

You're a little nervous, and understandably so: Black holes have a reputation as dangerous and untrustworthy pets. Nothing could be further from the truth. A quantum black hole of moderate mass (up to a few billion tons) can be trained to follow you around like a puppy. The secret is in the care and feeding.

Like any pet, a black hole involves some serious responsibilities. Before getting into the details, let's review a few of its habits. First, a black hole will eat anything and everything that comes close to it, even its master. As long as you keep a reasonable distance, however, there is no danger. Blackie is about the size of an atomic nucleus, making it far too small to see.

But you can certainly feel Blackie: Its gravity pulls on you like a dog pulling on its leash. About eight feet from Blackie, its gravitational pull roughly equals that at the surface of Earth. But don't get much closer. At four feet away, its pull is four times Earth's, and at two feet, it rises to 16 times. At one foot, you might find *yourself* footless. The pull there is 64 times what your body is used to on Earth. If you were to approach Blackie feet first, your head would remain in near Earth-like conditions while your feet would be subjected to this enormous force. Your body would come unglued, with your feet ripped off and your head unaffected. With an affectionate pet like this, you have to be careful.

Your first job is to retrieve Blackie from orbit, though that's easier said than done. You could tow your new pet using a spaceship and the gravitational



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attraction between the two. One way would be to tether a thousand-ton ball at the end of a cable and dangle it near, like bait. At a distance of eight feet, the ball would attract Blackie with the force of a thousand tons. Unfortunately, this ball doesn't carry a lot of weight compared with Blackie's 900 million tons. And if you misjudge the distance, Blackie could swallow your bait in a flash — a flash of light and radiation.

Larry Niven suggests another method in his story "The Borderland of Sol." The villain of the piece manipulates his black hole by blasting it with ions until it acquires a large electric charge. He then tows it using an opposite charge. But this method suffers from the same disadvantage as gravity: The force drops off rapidly with distance. If you are too far away, the attraction is too small. And if you get too close, Blackie will chase you faster than you would like. There's another problem: The charge wouldn't last. Blackie would quickly swallow all the opposite charges in its vicinity and become neutralized.

A slightly better method would be to give Blackie and your ship the same electric charge. Because like charges repel, you would be pushing Blackie instead of towing. The closer you approach, the greater the force. And by pushing, it wouldn't matter how close you came — an excellent safety feature. Nevertheless the problem of Blackie's neutralizing its own charge remains.

Arthur C. Clarke, in *Imperial Earth,* discusses how black holes could actually power a spaceship. That would be ideal. You need to harness Blackie like a husky and have it pull your "spacesleigh" around. It's actually quite simple to harness Blackie: It's all in the feeding.

Whenever Blackie swallows something, it emits a belch of radiation. As the radiation blasts away from the point of impact, a recoil force works against Blackie, pushing it in the opposite direction. Whenever you want to go in a certain direction, just toss a few tons of "bones" on the opposite side of Blackie and along you go.

You need only one small addition to this system, a leash. That's not as tough as it sounds. Place your ship directly in front of Blackie with its rear protected by a large radiation shield. Three long arms reach out behind and around your pet. When you want to go forward, just lob a few tons of bones toward Blackie's rear. It lets out a belch and moves forward. Then toss in a few pounds from the front. Blackie lets out a little belch and slows

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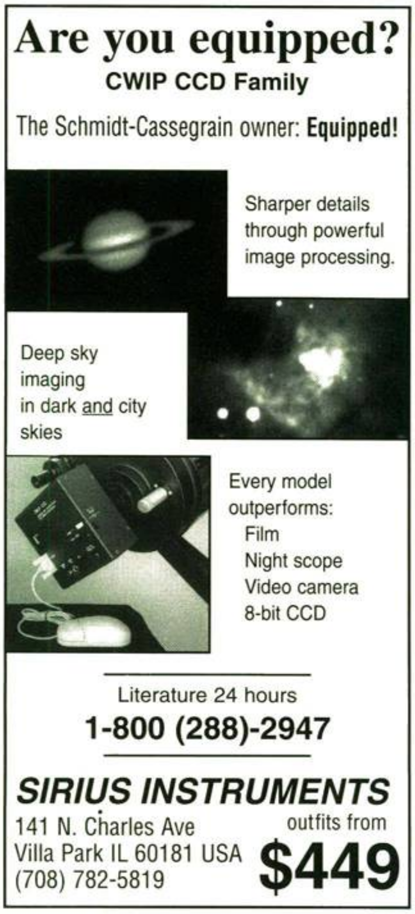

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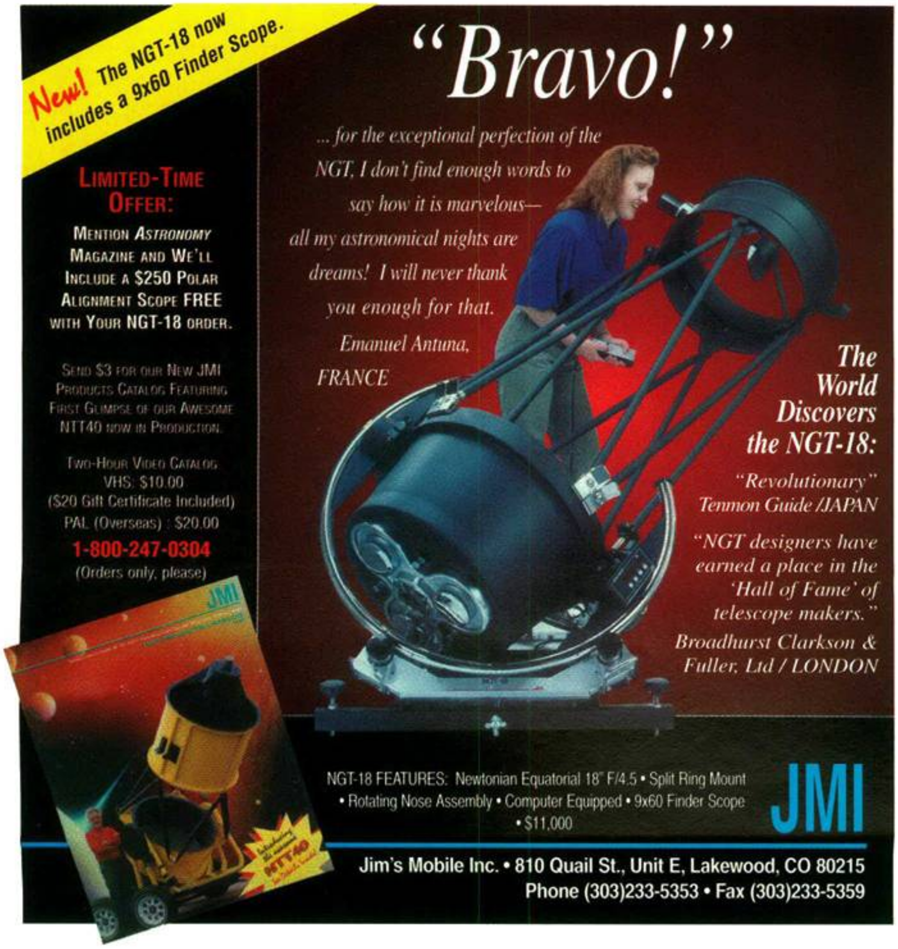

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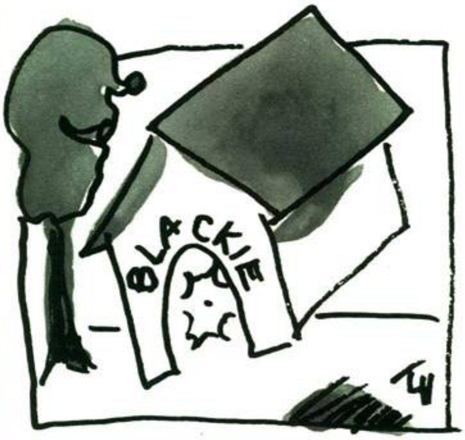

down a trifle. The radiation traveling forward strikes the radiation shield and pushes you forward. In this manner Blackie moves forward, and as it does it pushes you along. For steering, simply aim your shots a little to one side or the other. That's all there is to it.

A word of caution about bringing Blackie home: Most municipalities don't allow large pets to be kept within city limits. And a black hole can become bad-tempered if not fed regularly. Of course you can support your pet on Earth's surface, but it requires an enormous amount of food to keep Blackie balanced. Even then it swallows a steady stream of atmosphere as a dessert. If you neglect its feeding for even an instant, Blackie will start to settle into the ground. As soon as it does, it will swallow some, belch, dig deeper, and gradually bore toward the center of Earth. All of this makes a frightful racket that can be heard for thousands of miles. The neighbors won't like it at all, nor will they appreciate the radiation. So unless you have a lot of land, you'd better find a boarding kennel in orbit.

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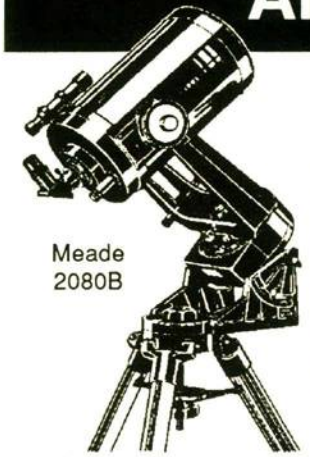
Black holes make excellent pets. They never suffer from illness and they can live for millions of years. I'm sure you will enjoy your pet very much. Just remember it can be very affectionate, so don't get too close! ☐

Walter C. Driedger is a process control engineer living in Calgary, Alberta.



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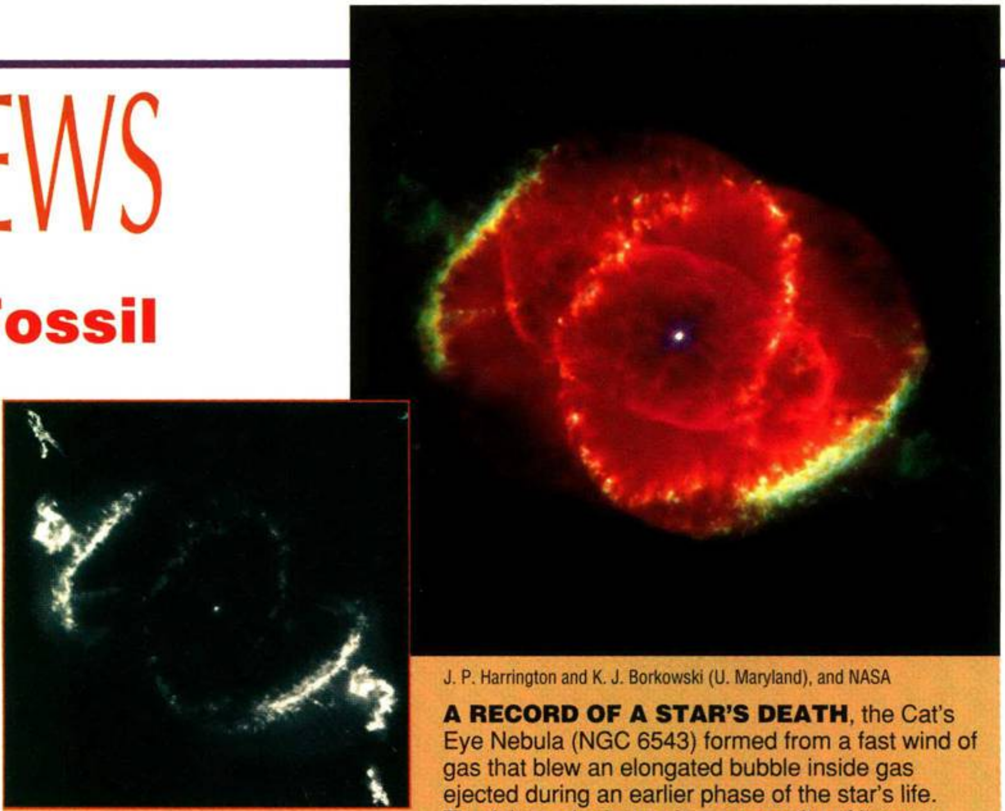
ASTRO NEWS

A Stellar Fossil

Planetary nebulae are "fossils" whose gassy tendrils record the death throes of stars like the Sun. While many such death shrouds are visible through ground-based telescopes, the Hubble Space Telescope provides uniquely sharp views of the intricate structure of planetary nebulae. In September 1994, Hubble's Wide Field/Planetary Camera 2 imaged NGC 6543, nicknamed the Cat's Eye Nebula, and uncovered its concentric gas shells, jets of high-speed gas, and bright knots of gas. The nebula is about a thousand years old and lies 3,000 light-years away in the constellation Draco.

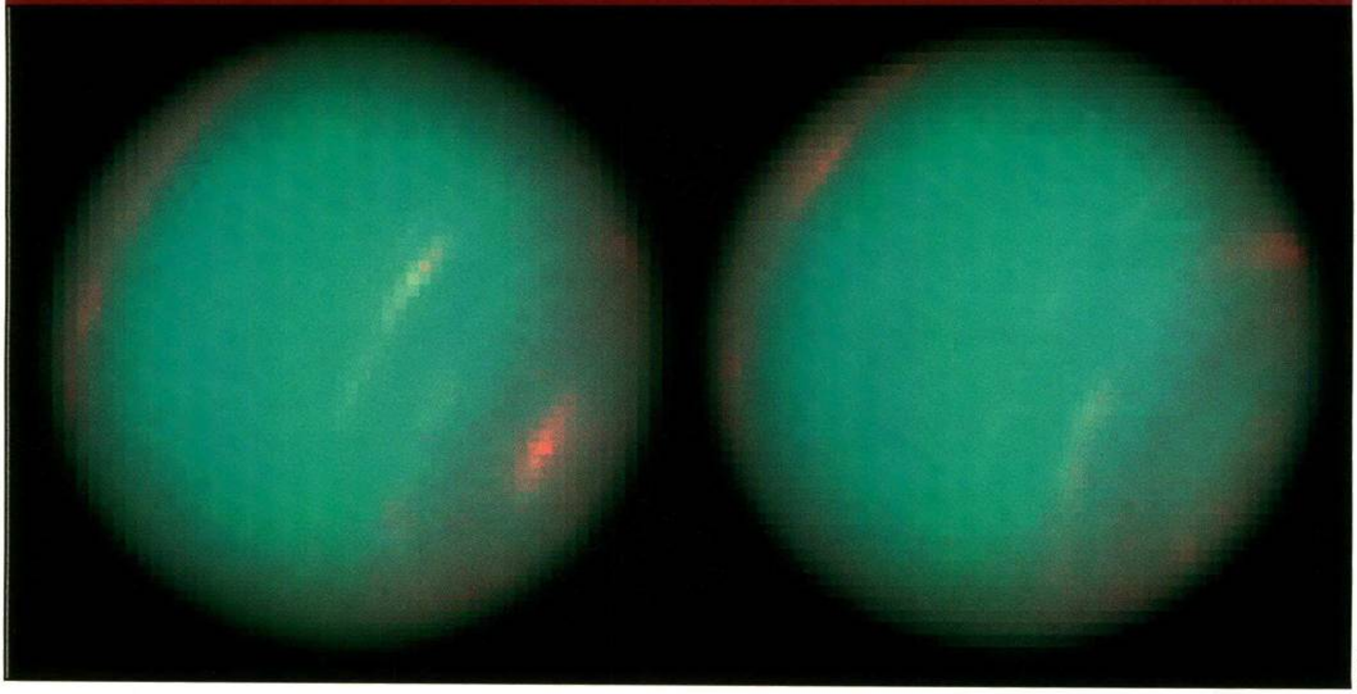


J. P. Harrington and K. J. Borkowski (U. Maryland), and NASA

A RECORD OF A STAR'S DEATH, the Cat's Eye Nebula (NGC 6543) formed from a fast wind of gas that blew an elongated bubble inside gas ejected during an earlier phase of the star's life. The false-color image is a composite of images taken by the Hubble Space Telescope in red hydrogen light (red in the image), the red light of nitrogen with one electron removed (green), and the orange-red light of oxygen (blue). The black-and-white image more clearly shows the equatorial ring and the bright arcs created by a companion star.

Neptune Sheds a Spot

IMAGES TAKEN NINE HOURS apart by the Hubble Space Telescope last July show a wealth of wispy white clouds instead of the expected Dark Spot. Pictures to be shot this summer should tell astronomers more about the planet's enigmatic atmosphere.



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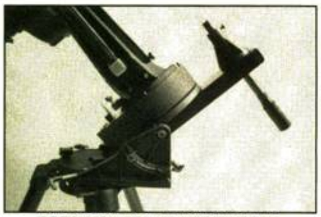
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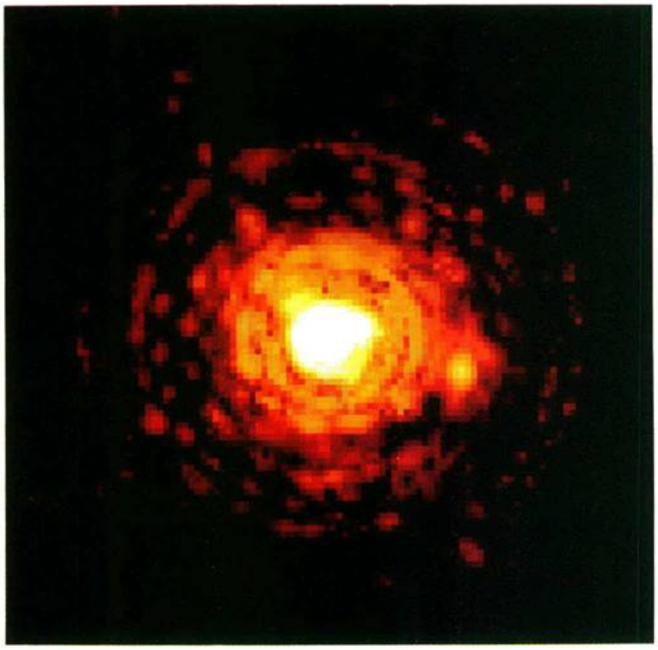
J. Patrick Harrington and Kazimierz Borkowski of the University of Maryland-College Park observed the nebula and later suggested an explanation for its structure at the American Astronomical Society meeting in Tucson in January. They propose that the nebula contains two stars too close together to resolve with HST, the dying star that produced the nebula and a companion. The dying star in an earlier phase blew off the two lobes of gas (red in the false-color image). Later, the star ejected a high-speed wind that formed the elongated shell of glowing gas seen inside the lobes. Dense gas, presumably ejected along the companion star's orbital plane, pinches the lobes and forms a bright ring.

The suspected companion, accumulating material blown off by the dying star, may generate two high-speed gas jets lying at right angles to the ring. These jets would compress gas ahead of them, which would explain the "curlicue" features and bright arcs near the edges of the lobes. Such views of planetary nebulae will enable astronomers to understand the processes that shape them.

Big News from Small Stars

Astronomers have long thought that an unseen companion, a brown dwarf, orbited Gliese 623, a 9th-magnitude red dwarf star 23 light-years away in Lacerta. Now they have a glimpse of it. Otto Franz and Lawrence Wasserman of Lowell Observatory headed a team of scientists who used the Fine Guidance Sensors on the Hubble Space Telescope to target the binary star system. They found that the companion, Gl 623B, lies about two astronomical units from the larger star, Gl 623A, and that it has about 10 percent of the Sun's mass. (An astronomical unit is the distance between Earth and Sun.) This is close to the limit (0.08 solar mass) separating stars from the failed stars, the brown dwarfs. The new Hubble observations should help refine the separation between Gl 623A and Gl 623B and the mass and brightness of the latter.



C. Barbieri (U. Padua) and NASA/ESA

CAUGHT AT LAST! Hubble images of the faint companion to the star Gliese 623A in Lacerta will help astronomers distinguish stars from brown dwarfs.

Other Hubble observations using the Goddard High Resolution Spectrograph centered on another binary star, Gl 752, located 19 light-years away in Aquila. The larger of the two stars, Gl 752A, is a red dwarf about half the size of the Sun and contains about one-third the Sun's mass. Gl 752B, the companion, is more commonly known as Van Biesbroeck 10. It is smaller than Jupiter and contains only about 9 percent of the Sun's mass.

According to present models, such a small star should be unable to generate strong magnetic fields and, thus, outbursts such as flares. In October 1994, Jeff Linsky of the Joint Institute for Laboratory Astrophysics in Boulder, Colorado, and his team were surprised when they detected a flare on VB 10. Now theorists will have to figure out how this near brown dwarf produces a magnetic field.

Franz and Linsky presented their results at the American Astronomical Society meeting held in Tucson, Arizona, in January.

AMATEUR NEWS

Observatory's Second Chance

Hidden in a cluster of towering pines 20 miles outside of Detroit, Michigan, is the McMath-Hulbert Observatory. Henry Hulbert, Francis McMath, and his son Robert (for whom the McMath-Pierce Solar Telescope on Kitt Peak in Arizona is named), built the triple-towered observatory in 1930 to observe the Sun. In 1940 the University of Michigan took ownership of the towers near Lake Angelus. Three decades later they closed the observatory's doors.

The site remained idle until 1991 when local businessman James Kinsler purchased the building. To renovate the towers and scopes, he has assembled a team of dedicated amateur astronomers who call themselves the McMath-Hulbert Astronomical Society.

Members of the society now plan to restore the observatory and open it to showcase the site's history and contributions to solar astronomy. They also plan to use the observatory and its grounds to develop new technologies for use by amateur and professional astronomers interested in solar research. — *J. Robert Spencer*

Supersonic Jets Found in Galaxy M106

Astronomers using the Very Large Array radio telescope in New Mexico have discovered striking X-ray jets in the spiral galaxy M106,

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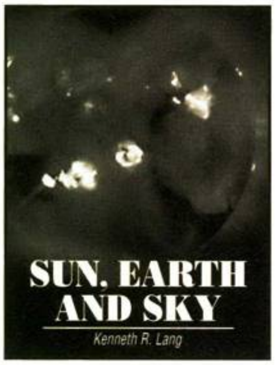

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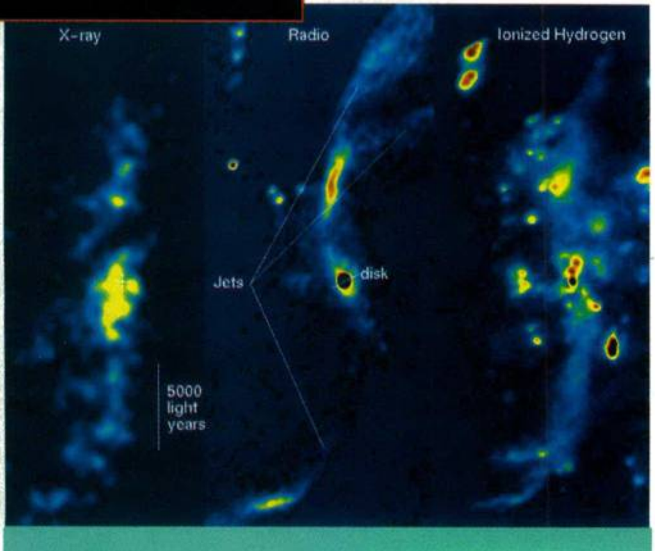
which lies 20 million light-years away in Canes Venatici. These jets are highly energetic, high-velocity streams of material flowing out from the galaxy's center that indicate the presence of a massive black hole. The central black hole accelerates material near the galaxy's nucleus and sends it shooting outward, narrowly focused into a beam. The finding may suggest how the massive black hole in the center of this galaxy has grown by interacting with its surroundings.

The discovery was made by Gerald Cecil of the University of North Carolina, Jon Morse of the Space Telescope Science Institute, and Sylvain Veilleux of the National Optical Astronomy Observatories. Such jets are relatively mysterious because they are so narrow, much narrower in relation to their lengths than a sewing needle. (The mechanism for focusing the jets and keeping them so narrow over such large distances is not clear.) Astronomers believe that a jet forms when hot gas expands supersonically through magnetized gas near a black hole. The jets in M106 are unique in that they can be observed in many frequencies of light, a fact discovered following the X-ray observations. Their interaction with the flattened region of gas and stars in the galaxy lights them up.

In visible light the jets show three strands of material that twist around each other in helices. The helical paths of the gas allow astronomers to estimate speeds because the strands occasionally point toward Earth as they move, allowing a measurement uncomplicated by unusual angles of the jet relative to Earth. Using the ROSAT X-ray satellite, Cecil's team found the jets in M106 extend across 30,000 light-years. "The observations show the galaxy's center has ejected material within the last 2,000 years," says Cecil. "The jet probably formed 20 to 50 million years ago, and still has an abundant supply of dense molecular gas to feed on."

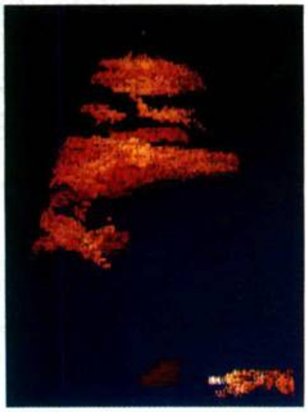
James R. Foster



Gerald Cecil, University of North Carolina

TWISTING FROM THE GALAXY'S CENTER, astrophysical jets inside M106 may betray a black hole at the galaxy's center. The X-ray view (left) shows extremely hot gas lying along the plane of the jets, which is visible in radio wavelengths (middle). The ionized hydrogen view of the same area (right) shows the clumps of gas influenced by the jets as well as regions of star forming regions. M106 (inset) is a bright spiral in Canes Venatici visible in any backyard telescope.

3D Map Reveals Bubble in LMC



Jun Xu and Arlin P. Crotts, Columbia University, and William E. Kunkel, Las Campanas Observatory

A 3-D MAP OF SPACE shows dust in the direction of Supernova 1987A in the Large Magellanic Cloud. The green asterisk marks the position of the supernova, and the direction of Earth is at bottom. The two large gas shells in front of the supernova compose a large superbubble filled with hot gas. The bubble was sculpted by the hot winds from stars within it.

A recently completed three-dimensional map displays the structure of the dust and gas between Earth and Supernova 1987A in the Large Magellanic Cloud. The supernova erupted eight years ago in this satellite galaxy of the Milky Way and was the brightest explosion recorded in modern times. Ever since it has been the subject of intense study. Astronomers made the newest announcement of a discovery linked to Supernova 1987A at the American Astronomical Society meeting in Tucson in January 1995.

Astronomers Jun Xu and Arlin P. Crotts of Columbia University and William E. Kunkel of Las Campanas Observatory studied the region of Supernova 1987A with a computer program that combined many observations into a picture of about 200 million cubic light-years of the LMC. This shows a superbubble of gas that records the star-forming history of the galaxy.

Reflecting light from the supernova explosion, the superbubble, visible as shells of gas near the center of the image, spans some 2,000 light-years. Several ancient bubbles of gas merged to form this giant and began a round of starburst activity in the galaxy. This subsequently sculpted and expanded the hot bubble from intense stellar winds.

In other news on Supernova 1987A, Crystal L. Martin and W. David Arnett of Steward Observatory employed computer simulations to examine how the supernova produced ring-shaped structures after exploding as a blue supergiant, rather than during the more likely red supergiant stage. They found that the progenitor star might have emitted a fast wind of material that collided with a

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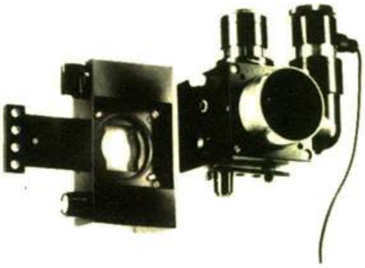

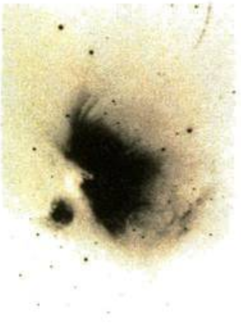

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shell of mass from an earlier red supergiant phase of the star's life. That scenario could account for the ring shapes, the astronomers believe.

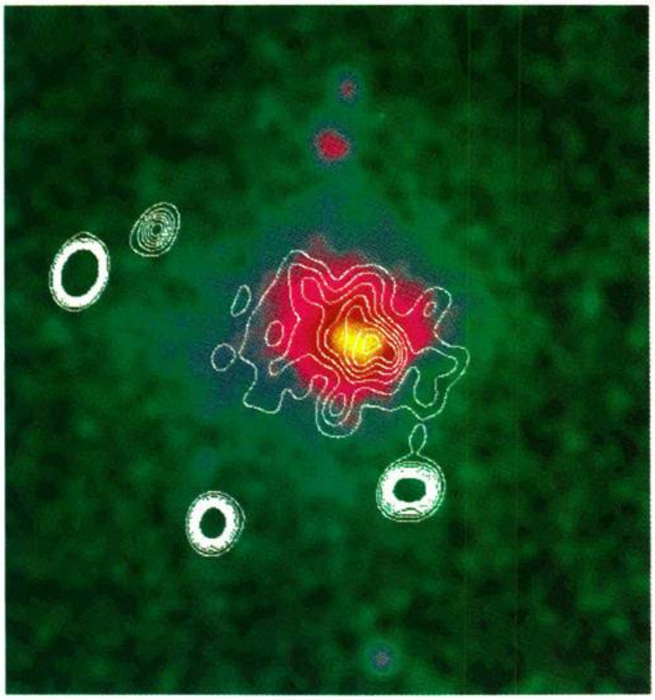
Powerful Object Found in Galaxy Cluster

A team of astronomers led by Thomas Herbig of Princeton University has announced the discovery of a massive radio- and X-ray-emitting object in the center of the galaxy cluster Abell 2163.

"The significance of this object," says Herbig, "is that its brightness exceeds by tenfold the brightness of previously known objects in its class and that it lies in the center of a cluster of galaxies with the highest known X-ray temperature."

Abell 2163 in Ophiuchus has been known for several years to be a particularly massive cluster of galaxies that emits X-ray radiation especially strongly. The temperature of the X-ray-emitting gas is 150 million kelvins, and the cluster has a mass about 3,000 times that of an ordinary galaxy. Of this, the X-ray-emitting gas makes up about one-third of the total. But finding a massive central object in Abell 2163 was a surprise.

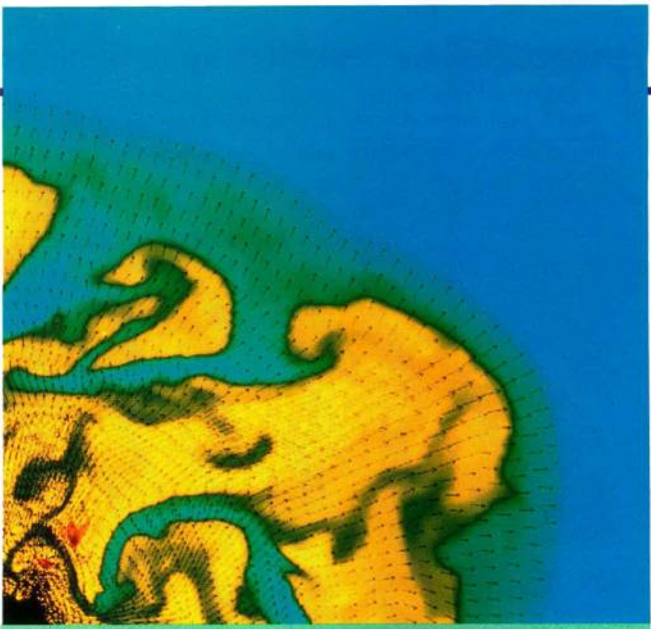
Says Herbig, "This will give us one of the best opportunities yet to understand the power source of this rare kind of object."



Mark Birkinshaw and Thomas Herbig

A MASSIVE OBJECT AT THE HEART of the distant galaxy cluster Abell 2163 is a powerful emitter of X rays and radio waves. Astronomers hope this object (central contour lines) may tell them more about the evolution of galaxies.

How Stars Explode



Adam Burrows, U. Arizona, et al.

STARS EXPLODE UGLY. When a massive star goes supernova, new computer models (above) show that the violence begins with roiling plumes of gas around the star's core, bottom left.

A massive star ends its life with a bang — a supernova. But astronomers' models of such a star have fizzled. Usually, the model star would swallow itself and form a black hole rather than explode as a supernova. Fiddling with the model could ignite a supernova but theorists considered that an embarrassment because real stars don't seem to require tweaking to explode.

Astronomers presented a solution to the problem at the January meeting of the American Astronomical Society in Tucson. Willy Benz of the University of Arizona and Marc Herant of Los Alamos National Laboratory in New Mexico suggest that early one-dimensional models were too simple and didn't allow material to flow in and out of the star's core; their 3-D model allows material to flow around the core. Their model star explodes naturally after it exhausts its nuclear fuels. As a final test of their idea, the scientists translated the 3-D gas motions back into a 1-D model — the model star again refused to explode. So they conclude that proper modeling of gas motions around the core is needed to understand the final moments of a star that is becoming a supernova.

Adam Burrows and John Hayes of the University of Arizona and Bruce Fryxell of NASA Goddard Space Flight Center in Greenbelt, Maryland, also presented supernova model results at the meeting. Their 2-D models show how the explosion erupts from the star's core in powerful, crooked plumes. Immediately after the core collapses, matter heated by neutrinos emitted by the core moves up and down just outside the core, forming fingers. The energy of the neutrinos during these early phases defies belief: It is about equal to the total optical energy output of the universe.

About 0.1 second after the core collapses, the wind of neutrinos helps drive the explosion of the supernova along the fingers. Because the fingers aren't symmetric around the star, the explosion can eject the core, now a neutron star, into space at speeds of hundreds of kilometers per second. This explains why astronomers have been able to observe some neutron stars at great distances from their supernova remnant. ☐

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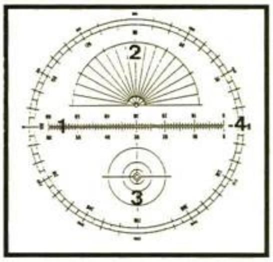

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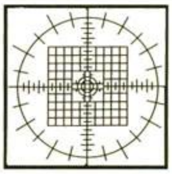
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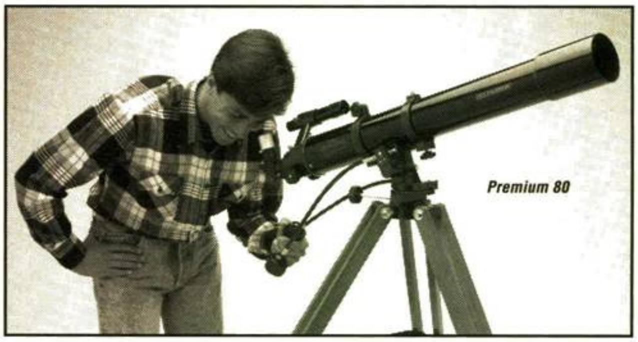
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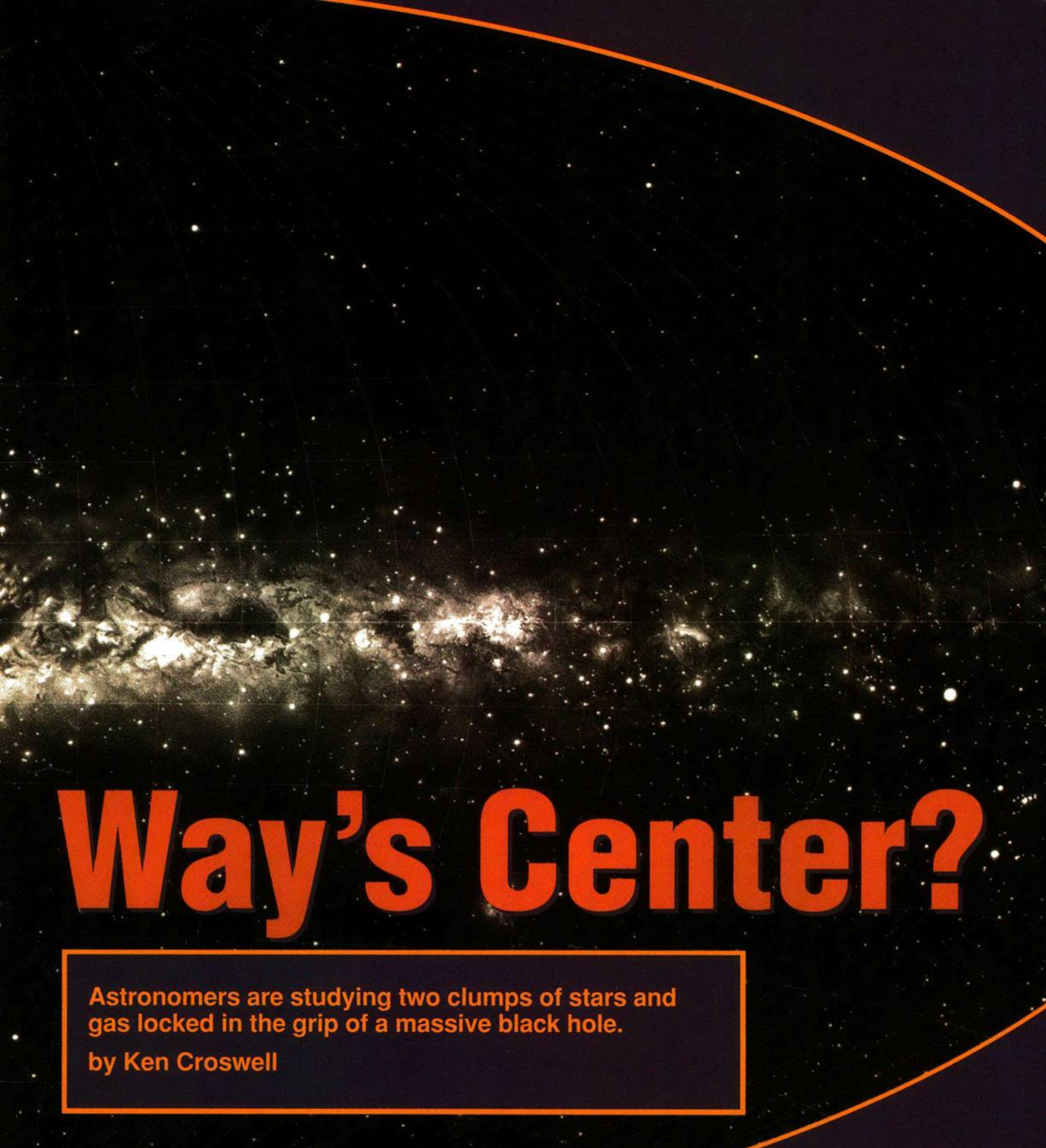
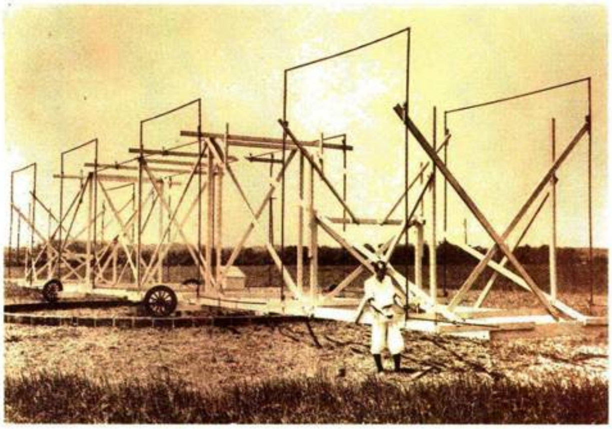


Way's Center?

Astronomers are studying two clumps of stars and gas locked in the grip of a massive black hole.

by Ken Croswell

Lund Observatory



Bell Laboratories

KARL JANSKY, aged 27, accidentally discovered radio waves from the Milky Way in 1932 using this primitive telescope. This began the journey of exploration to map distant parts of the Galaxy.

HAVENS OF STELLAR RECYCLING, emission nebulae like NGC 6334 in Scorpius are star factories in which aged gas transforms into infant suns. Such inhabitants of the Galaxy typify its contents away from the center.

Michael Stecker

Like a city's central business district, the galactic center is a crowded collection of a huge number and variety of objects. Within just one light-year of the galactic center are millions of stars of all colors, caught in the stranglehold of what may be a massive black hole.

Astronomers traveled slowly into the Galaxy before they approached its center, indeed before they discovered it *had* a center. Decades ago, astronomers armed with huge telescopes began compiling a photographic catalog of the citizens of our Galaxy — not just stars, but softly glowing gas clouds, tightly packed clusters of infant suns, and dark clots of dust packed along the panorama of light called the Milky Way.

More than 60 years ago the infant science of radio astronomy carried us out beyond where the optical light would take us. Other wavelengths such as infrared would help astronomers grope their way toward the invisible center of the Galaxy. Only recently would they discover that a monster probably lurks there, a massive black hole that shreds massive stars like paper.

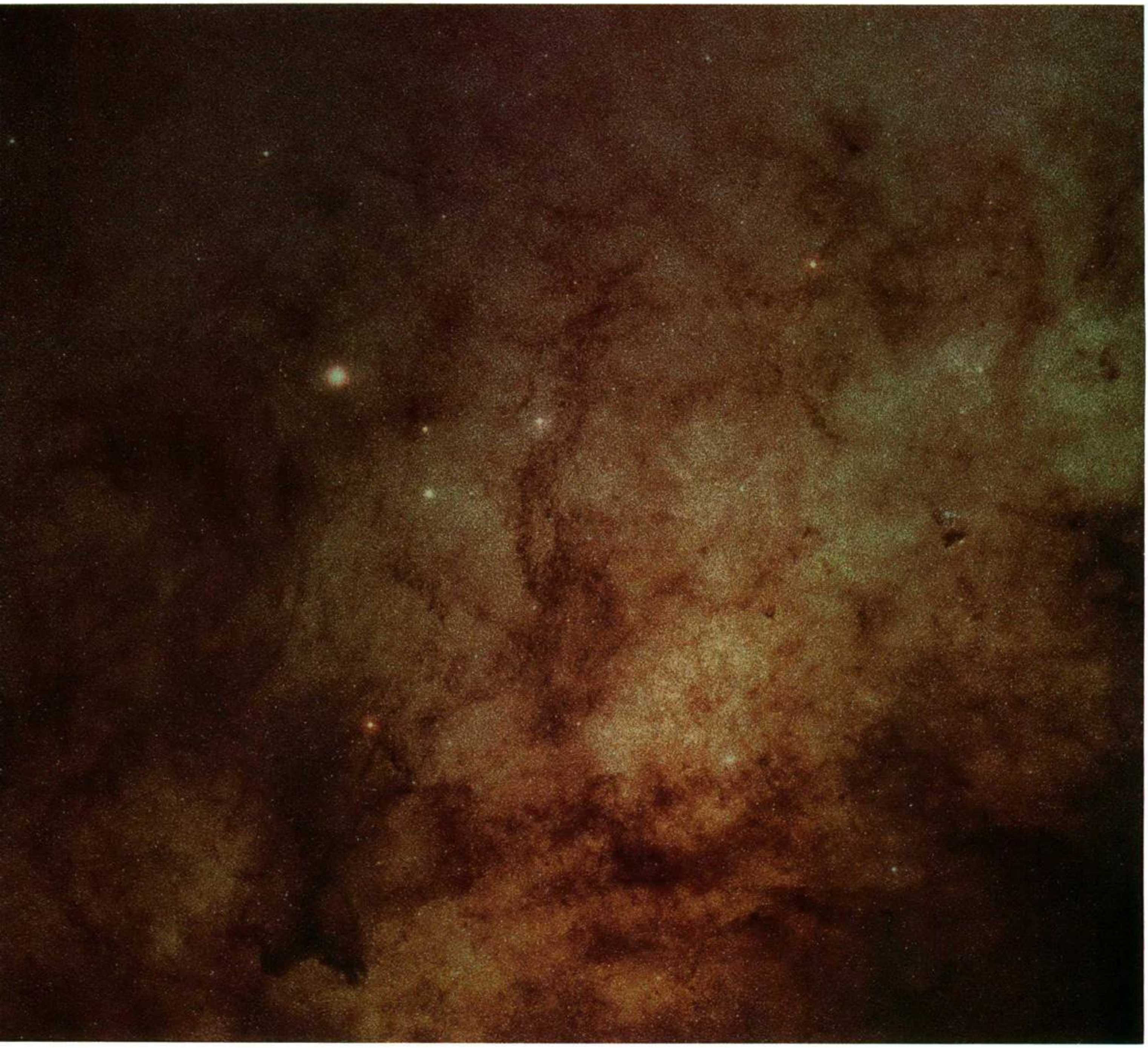
It is just this possibility that attracts Farhad Yusef-Zadeh, a radio astronomer at Northwestern University. "I study the galactic center because it holds so many types of features in such a small area of sky," says Yusef-Zadeh. "Each puzzle we solve leads to a new and exciting puzzle. It isn't planned this way — it just happens because of the incredible richness of this part of the Galaxy."

The galactic center offers unique insight into the nuclei of other galaxies. In the Milky Way, says Yusef-Zadeh, "we can study structures one light-year across, even a tenth of a light-year. We can't do that in other large galaxies." That's because even the nearest such galaxy, the great spiral in Andromeda, is 90 times farther away than the Milky Way's center, which lies 27,000 light-years from Earth.

"We can get a much more detailed picture of a massive black hole at the galactic center than at any other place in the universe," he says. Massive black holes probably lie at the centers of most giant galaxies, and they also power the great luminosities of quasars, heating infalling material so that it radiates profusely.

Nearly everything that astronomers know about the Galaxy's inner sanctum has come from radio observations, such as those by Yusef-Zadeh, and from infrared observations. Both radio and infrared radiation penetrate the gas and dust cloaking the Galaxy's center. Visible light, by contrast, does not: If a trillion photons of yellow light set out from the galactic center and raced toward us, only one would make it to Earth.

Historically, radio astronomers reached the galactic



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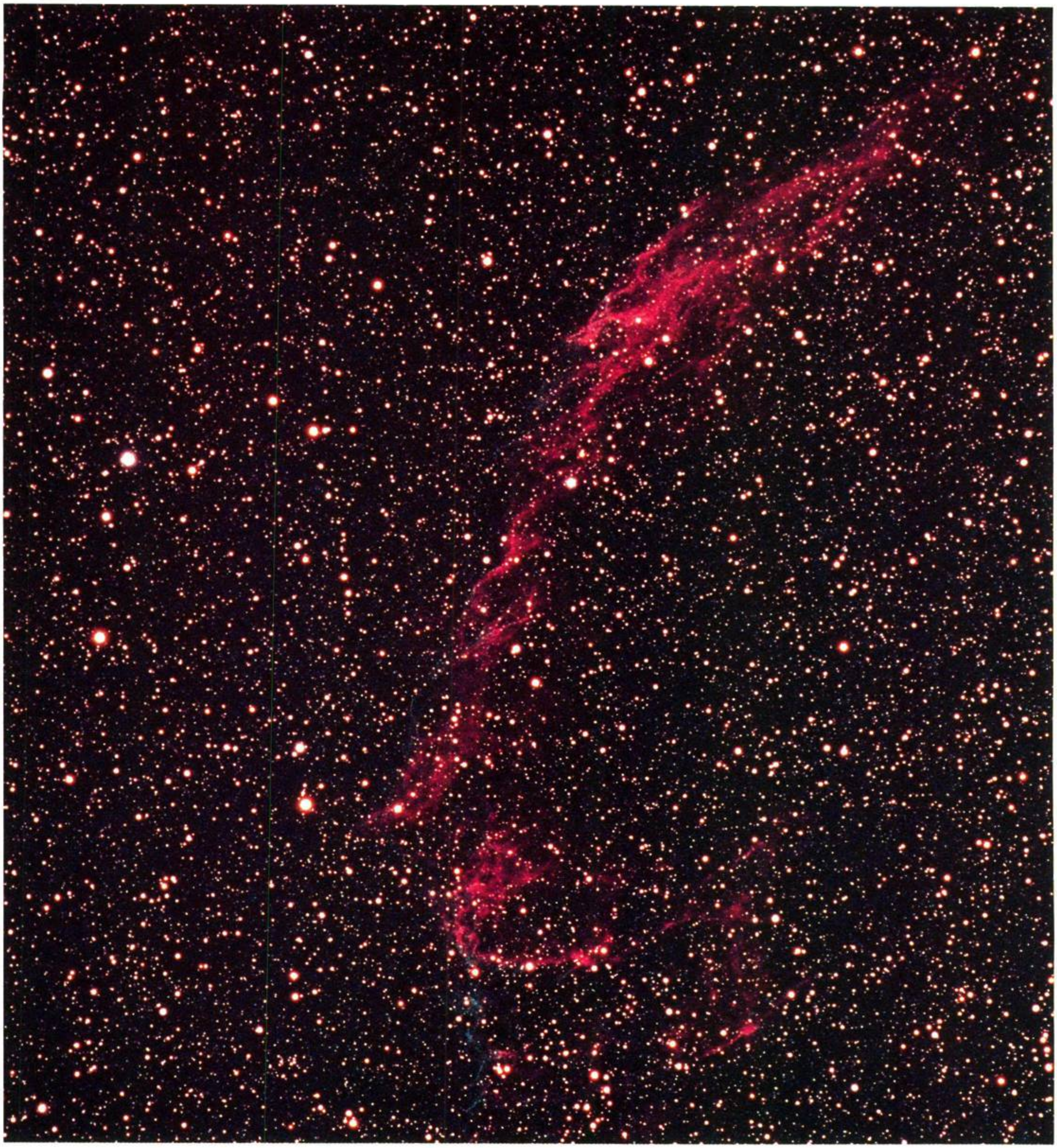
center long before their colleagues working in the infrared wavelengths. In 1932, when Karl Jansky discovered extraterrestrial radio waves, his strongest source lay near Sagittarius, home of the Galaxy's center. These radio waves arise from electrons in interstellar material and therefore let astronomers study the gas at the Galaxy's center. Three decades later, in 1966, two astronomers at Caltech, Eric Becklin and Gerry Neugebauer, first detected the galactic center's infrared glow, a form of radiation that comes from stars. Infrared wavelengths are longer than those of visible light, and cool stars such as red M-type giants emit more infrared radiation than visible light, just as they emit more red light than blue.

At the galactic center, hotter stars also appear brightest in the infrared because their visible light is absorbed by the intervening dust that infrared radiation penetrates. Radio and infrared observations therefore

A LABYRINTH OF STARS AND GAS inhabits the Sagittarius arm of the Galaxy, a crowded district between the Sun and the center of the Milky Way. Here the stars crowd together into their highest density anywhere in the sky.



Jerry Lodriguss

BLOWN APART AS A STAR DIED, *the gas in the supernova remnant NGC 6992-5 floats majestically outward, dissipating into the darkness. Such events seed the Galaxy with material for new stars.*

complement each other, the former probing the gas and the latter the stars. However, radio views are sharper and clearer because radio astronomers can combine separate antennae into huge arrays that mimic a single giant dish and reveal fine details in celestial objects.

Since 1990, radio and infrared astronomers have painted a picture of the galactic center so detailed that it is easy to lose the forest for the trees. Within one light-year of the Galaxy's center, however, three "trees" stand taller than the rest: a source of radio waves named Sagittarius A* (pronounced "ay star") that marks the very heart of the Galaxy and may be a massive black hole; a cluster of blue stars near Sagittarius A* named IRS 16 that may hurl material into the black hole; and a red supergiant named IRS 7 that gets blasted by IRS 16's ejecta and has a tail like that of a comet.

The Galaxy's Biggest Black Hole?

Of the three objects, Sagittarius A* has provoked the most excitement — and the most controversy. "Sagittarius A* is a unique object in the Galaxy," says Yusef-Zadeh. The point in the Galaxy about which all else orbits, Sagittarius A* emits five times more energy at radio wavelengths than the Sun does at visible ones, making Sagittarius A* the strongest radio source in the vicinity of the galactic center.

Sagittarius A* is probably a black hole, and its radio waves are the scream of a hot disk of gas that orbits the black hole before plunging in. This accretion disk is hot both because its material has converted gravitational energy into heat and because the material rubs against other orbiting material. The infalling material feeds the black hole and increases its mass. The black hole probably formed long ago, when one of the stars at the galactic center collapsed, and it then had only a few solar masses. But it grew more and more massive as it swallowed nearby stars and the debris shed by more distant ones. Today, Sagittarius A* may harbor as much as a million solar masses. That a massive black hole lies at the galactic center was first suggested by British astronomers Donald Lynden-Bell and Martin Rees in 1971.

NRAO

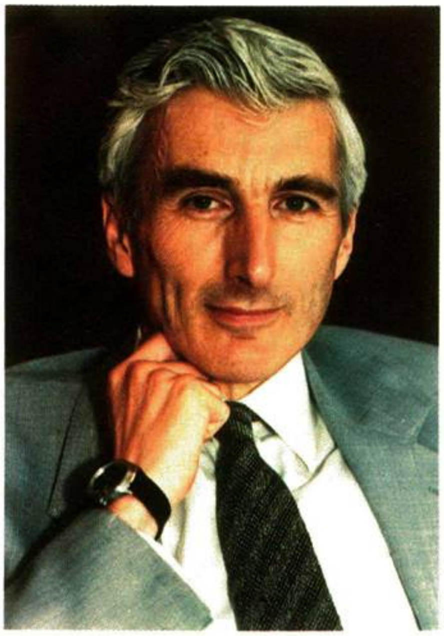
SAGITTARIUS A* is the mysterious double-lobed object nearest the center of the Galaxy. This radio image shows the energy from what may be giant clumps of stars and gas swirling around a central black hole.

But it is not yet certain that Sagittarius A* is a black hole. "If you want proof," says Yusef-Zadeh, "unfortunately we don't have it. It's difficult to prove that a black hole lies in the center of any galaxy. But we have a much better chance of determining the mass of a black hole in the Milky Way, in our cosmic backyard, than in the center of any other galaxy."

The trouble is that black holes by their very nature are tough to study. Even the existence of an ordinary black hole, which forms from the collapse of one star, is difficult to prove. Although the Galaxy probably contains roughly 100 million black holes, astronomers have found only four good candidates in the Milky Way, including Cygnus X-1 and A0620–00. In these systems, a normal star circles an invisible one so quickly that the invisible star's mass probably represents a black hole.

Although black holes have more mass than the Sun, physically they are not especially large. Sagittarius A*'s radio waves emerge from a region that is less than the diameter of Earth's orbit around the Sun, which is just a few light-minutes across. Furthermore, the radio source is elongated, like a black hole's accretion disk seen edge-on. In 1991, a team of German astronomers discovered an infrared source at the position of Sagittarius A*. If this infrared radiation comes from Sagittarius A*, it further supports the existence of an accretion disk, because the radiation is blue before it gets reddened by dust. The blue color signals something hot, like a black hole's accretion disk.

If Sagittarius A* is a black hole, however, it far outweighs an ordinary stellar one like Cygnus X-1. Astronomers know this because Sagittarius A*'s proper motion shows the object to be at rest with respect to everything else in the Galaxy. To remain so still, Sagittarius A* must be fairly massive. Most astronomers, including Yusef-Zadeh, believe Sagittarius A* contains about a million solar masses. The best evidence for such a high mass is that stars and gas near Sagittarius A* whirl around it extremely fast. Their high speed probably arises because they feel the strong gravitational pull of a million-solar-mass black hole. However, those astronomers who do not believe in the existence of such a massive black hole claim that most of this mass resides in a dense cluster of stars near Sagittarius A* and that Sagittarius A* itself has only a few



Martin J. Rees

MARTIN REES of Cambridge University was in 1971 one of the originators of the idea that a black hole lurked in the center of the Milky Way.

George Greaney

DARK NEBULAE like those winding about the Rho Ophiuchi region hold much of the Galaxy's dust.

hundred solar masses. Some astronomers have even argued that stars alone can explain everything and that no black hole of any mass exists.

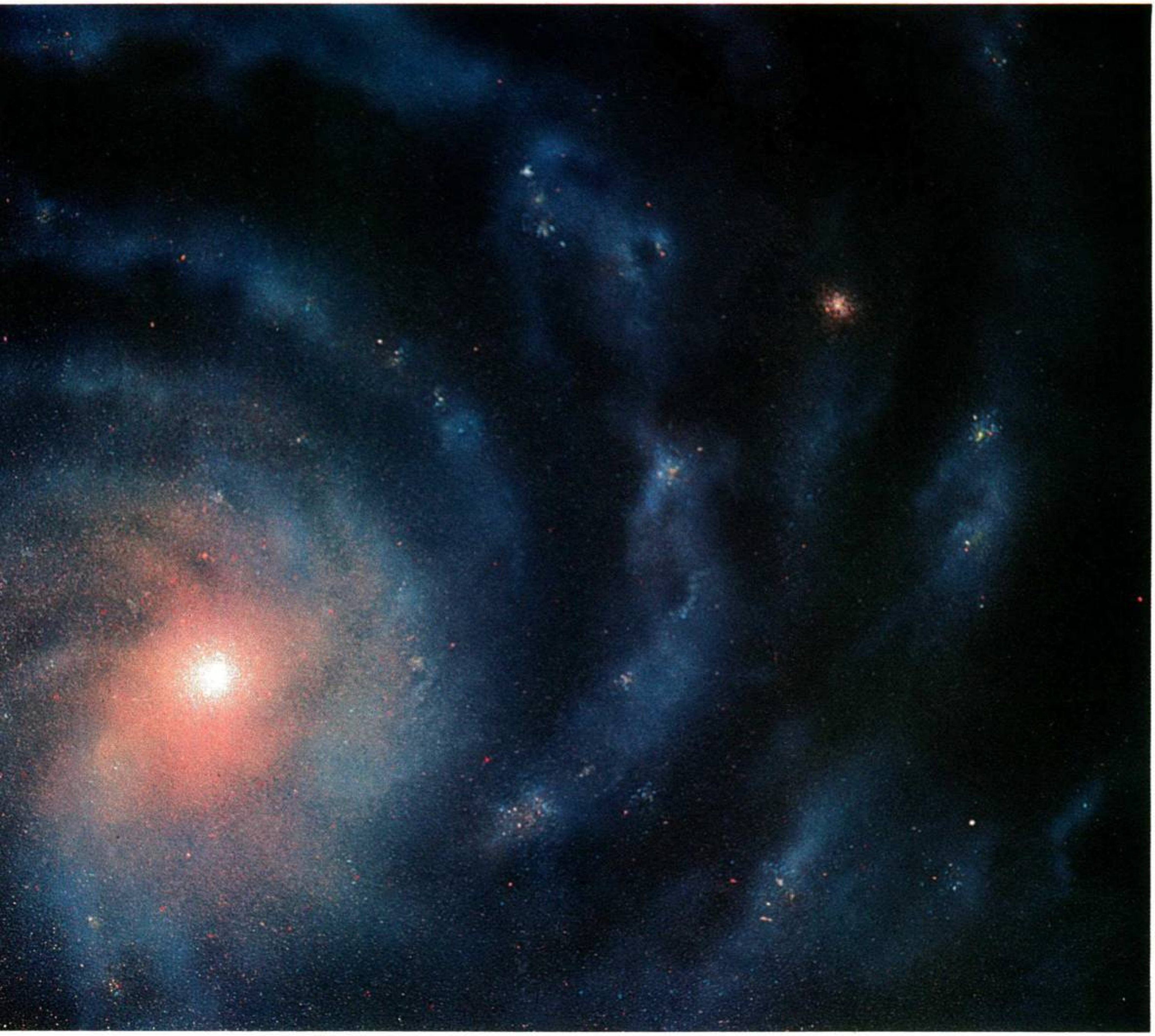
To settle the dispute, in 1992 Mark Wardle at Northwestern University and Yusef-Zadeh proposed a test that invokes Einstein's general theory of relativity to measure the mass of Sagittarius A*. Einstein's theory says that an object's gravity can bend light coming toward an observer from a source behind the object. Normally, light diverges, spreading out in all directions from its source, but the gravity of an intervening object can bend diverging light rays together. Because of this, as viewed from Earth, two or more images of the light source appear in the sky, each the result of a separate light ray. This so-called gravitational lensing was first seen in 1979, when astronomers spotted two images of the same quasar that sit side by side in the constellation Ursa Major. There are two images because a large galaxy lies between Earth and the quasar, and it lenses the quasar's light. In the same way, said Wardle and Yusef-Zadeh, Sagittarius A* should gravitationally lense the light coming from stars behind it.

"We have a very interesting situation right at the galactic center," says Yusef-Zadeh. "The density of stars is very large, and they're all surrounding what may be a million-solar-mass black hole. These stars have very high velocities, so the chance of seeing one of these stars go behind this massive black hole is very large. Gravitational lensing theory then tells us that this radiation passing through the space-time curvature of the black hole will get amplified."

If such lensing is detected, it would reveal whether Sagittarius A* has a million solar masses, as most astronomers suspect, or only a few hun-

Dewey Hentges

"It's difficult to prove that a massive black hole lies at the center of any galaxy. But the Milky Way gives us a better chance than other galaxies do."
— Farhad Yusef-Zadeh



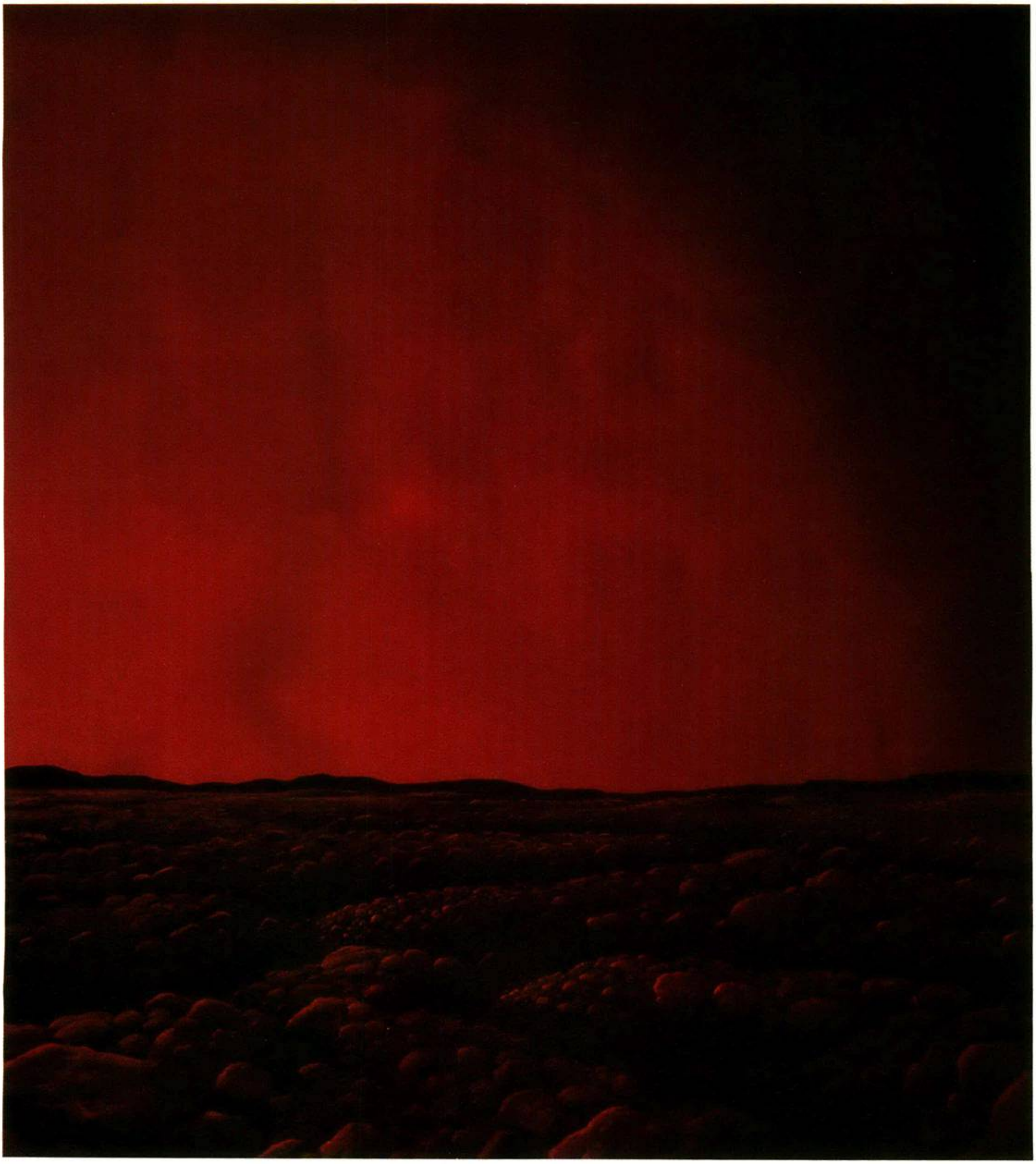
William K. Hartmann

dred. Yusef-Zadeh believes that the infrared is the best region of the spectrum in which to perform the test, but it requires better resolution than infrared telescopes currently achieve. However, Yusef-Zadeh thinks that infrared astronomers will attain the necessary resolution in the next five to ten years.

In fact, in just the last five years, infrared astronomers have stormed into the galactic center with sensitive arrays of infrared detectors that provide sharp views of its stars. In 1992, astronomers in Germany led by Andreas Eckart and Reinhard Genzel swept through the galactic nucleus and detected 340 individual stars within 1.3 light-years of Sagittarius A*. These stars are presumably the brightest members of the dense cluster that inhabits the Galaxy's central few light-years.

"That was an excellent piece of work," says Yusef-Zadeh. "We already knew a great deal about the gas from the radio work. Now this infrared-array technology has been able to tell us something about the stars very near the center. It's definitely the way to go."

THE PANORAMA OF THE GALAXY unfolds in this illustration by astronomer William K. Hartmann. The Milky Way is a typical Sb-type spiral, and some 27,000 light-years separate the galactic center (left) from the Sun's neighborhood, several spiral arms outward (right, center).



Adolf Schaller

THE SUN SWELLS into a red giant some five billion years into the future. Even the environments most friendly to life in the Galaxy are only temporarily so on cosmic timescales. Ultimately, humans will need to find another vessel — or go down with the ship.

IRS 16 and IRS 7

Lying just over a tenth of a light-year from Sagittarius A* is a second major actor in the galactic hub, a bright object named IRS 16 (IRS for infrared source). During the 1970s, when astronomers first catalogued it, IRS 16 appeared to be just one object. More recently, however, high-resolution infrared pictures have revealed it to be a cluster of at least 25 stars. Although their light looks red because of the intervening dust, most of IRS 16's stars are actually blue, which suggests that they are blue supergiants similar to Rigel. A blue supergiant loses mass in a stream of particles called a wind, and the stars of IRS 16 blow a wind that ejects several Earth masses a day. The wind from IRS 16 may fuel Sagittarius A*'s accretion disk, replenishing it with material.

This accretion of material distinguishes the Milky Way from Andromeda, whose center may harbor a black hole over ten times as massive as Sagittarius A*. Still, despite the greater mass, Andromeda's black hole packs less than a tenth the radio punch of Sagittarius A*. "I think it all depends on how much gas a galaxy holds," says Yusef-Zadeh, since more gas means more accretion by the black hole and a luminous accretion disk. "Andromeda seems to be very pristine, very clear of gas, compared with the nucleus of our Galaxy." But the best indicator of IRS 16's wind comes from the galactic center's brightest infrared source, IRS 7. One of the most remarkable stars at the Galaxy's hub, IRS 7 is a red supergiant similar to Antares that lies less than one light-year from the galactic center. IRS 7 is therefore captive by Sagittarius A* and gets blasted by the wind from IRS 16.

Like all red supergiants, IRS 7 loses mass in a wind, but IRS 7's own wind is weak, with a velocity of only 25 kilometers per second. By contrast, IRS 16's wind travels at 700 km per second. This powerful wind smacks into IRS 7's and pushes it away, producing a long tail on IRS 7 that points away from IRS 16. The same phenomenon occurs in the solar system, where the solar wind buffets material ejected by a comet, creating a tail that points away from the Sun. IRS 7's cometary tail was discovered in 1990, from radio observations conducted by Yusef-Zadeh and Mark Morris, of the University of California at Los Angeles, and independently from infrared observations made by a team led by Caltech's Gene Serabyn.

Together, Sagittarius A*, IRS 16, and IRS 7 form a triad that resounds throughout the galactic center. As a likely black hole, Sagittarius A* is the gravitational anchor about which IRS 16 and IRS 7 pivot, while IRS 16 blows a strong wind that fuels Sagittarius A*'s accretion disk and gives IRS 7 a "cometary" tail.

They mark the Milky Way's very heart, the point about which the rest of our mighty Galaxy revolves. ☐

Luke Dodd

THE BRILLIANT ORION ARM of the Milky Way reveals itself on any winter evening. The Galaxy's soft glow passes through Orion's bright blue and white stars, revealing thousands of stars in the direction opposite our Galaxy's center, toward its edge.

This article is excerpted from The Alchemy of the Heavens: Searching for Meaning in the Milky Way, *published by Doubleday/Anchor.*

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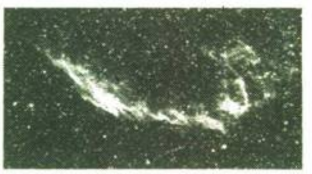

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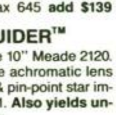

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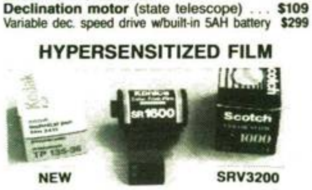

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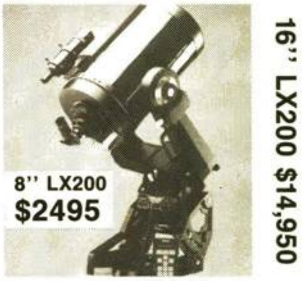
1¼'' O.D. plug, seals focuser	**4/$2**		
2'' O.D. plug	**2/$2**	3½'' O.D. plug	**$1.50**
1¼'', 1⅜'' ...	**3/$2**	7½''	**$10**
1½''	**2/$2**	9½'', 10.4''*	**$15**
2''	**2/$2**	12½'', 12⅞''* ...	**$20**
2⅛''	**2/$20**	15.6'', 16''*	**$28**
5½''	**$6**	19'' (DS-16)	**$35**
*Fits Odyssey		21'' (Odyssey-II)	**$35**

MEADE 8'' - 16'' LX200 SCHMIDT-CASSEGRAINS



NEW Meade 8'' LX200 Telescopes

LX100 - includes wedge, best for photography.
LX200 - full computer control w/64K obj. mem.
NOTE: A wedge is **not** needed for visual observing with the LX200 Drive. Select f/10 or f/6.3 (no extra charge) for your Schmidt-Cassegrain.

8'' **LX100** with wedge ($105 P&S)	**$2095**
8'' **LX200** w/computer ($105 P&S)	**$2495**
Wedge for photographing w/8'' LX200 ..	**$139**
10'' **LX100** w/super wedge ($145 P&S) .	**$2895**
10'' **LX200** w/computer ($145 P&S) ...	**$2895**
12'' **LX200** (f/10 only)($215 P&S)	**$3995**
Super Wedge for photogr. w/10'',12'' LX200	**$395**
16'' **LX200** f/10 w/tripod ($385 P&S) .	**$14,950**
Dew Shields: 8'' .... **$119;** 10''	**$129;**
12'' .... **$189;** 16''	**$289**

OTHER SCHMIDT-CASSEGRAINS

Meade 2045D 4'' f/10 w/motor ($40 P&S)	**$699**
Meade 2080B 8'' f/10 w/tripod, wedge, MCOG ($95 P&S)	**$1249**
Model 2120B 10'' f/10 w/wedge, tripod, MCOG ($125 P&S)	**$1599**

PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4'', 8'', f/6 or f/10	**$249**
Giant EASY-GUIDER for 10''/12'' f/4-f/10 .	**$395**

MEADE STARFINDERS

New 8'' f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive (equat. only), mount, finderscope and 25mm (=48X) eyepiece.

6'' f/8 Dobsonian Starfinder ($46 P&S)	**$325**
6'' f/8 Equat. Starfinder 6(add $79 P&S) ...	**$599**
8'' f/6 Dobsonian Starfinder (add $59 P&S)	**$425**
8'' f/6 Equat. Starfinder 8 (add $89 P&S) ..	**$699**
10'' f/4.5 Dobsonian Starfinder ($85 P&S) ..	**$595**
10'' f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$799**
12.5'' f/4.8 Dobsonian Starfinder ($95 P&S)	**$795**
16'' f/4.5 Starfinder 16 (ship. freight COD) .	**$2495**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $99 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector .	**$99**
LUMICON DX200 Dual-axis drive cor.	**$249**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination ..	**$475**
LUMICON DX2BP Dual-axis drive corrector with built-in battery pack	**$299**

LUMICON® SKY VECTOR™

Higher Performance — Lower Price

LUMICON ACCESSORIES

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

LOW PRICE—from $399

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $399

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $499

IMPROVED — Planets, Over 3,700 Objects! With size, magnitude and full visual description.

NGC SKY VECTOR™ $699

IMPROVED!—5500 Additions / Corrections

NGC-Sky Vector
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON

Improved NGC SKY VECTOR with over 12,000 object memory including the planets, complete, corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth.

Ultima 8, 11 .. **add $25**, C-14 .. **add $75**

COMA CORRECTOR

Coma 1 inch off-axis 17½'' f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2'' lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2'' EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8''.

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2'' EASY-GUIDER .	**$189.50**
2'' EASY-GUIDER (Mamiya 645)	**$199.50**
2'' Adapter for Pentax 6X7 ...	**$129.00**
2'' Adapter for Hasselblad .	**$229.00**
2'' Adapter for Bronica SQ-A	**$175.00**
2'' Extension for viewing ...	**$26.00**

2'' DELUXE BARLOW

1.8x Multiplier Lens (2'' Barlow)

LUMICON 1.8x Multiplier Lens (2'' Barlow) **$235.00**

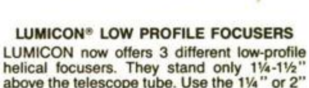
LARGE UV/DUST SEAL

Protect the optics of your 8-14'' Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080 ...	**$119.50**
UV/Dust Deal for Celestron C-8 ...	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14 .	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50



LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½'' above the telescope tube. Use the 1¼'' or 2'' versions for viewing. Use the 2'' non-rotating focuser for convenient photography with the LUMICON 2'' EASY-GUIDER™.

Select your desired base-plate shape! Coulter Odyssey (thread-on installation), Flat, 7'' OD, 9½'' OD, 12½'' OD, 16'' OD, 21'' OD.

LUMICON 1¼'' Helical Focuser	**$69.50**
LUMICON 2'' Helical Focuser 1½'' high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2'' Astro Systems focuser, only 2'' high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2''/1¼'' adapter w/48mm filter threads	**$20.00**
2'' LUMICON EASY-GUIDER	**$169.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼'' 50mm Finderscope **$69.50**, right-angle	**$69.50**
1¼'' straight-thru 80mm SUPER-FINDER .	**$179.50**
1¼'' right-angle 80mm SUPER-FINDER ..	**$189.50**
1¼'' right-angle version, w/star diagonal ..	**$239.50**
25mm Cross-hair 1¼'' eyepiece (12X)	**$49.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼'' Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼'' 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2'' adapter for C-8, Meade 2080, etc. ..	**$29.50**
2'' adapter for C-80, C-100 refractor ...	**$39.50**
2'' adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2'' adapter for C-6, Comet Catcher, Meade 312	**$30.00**

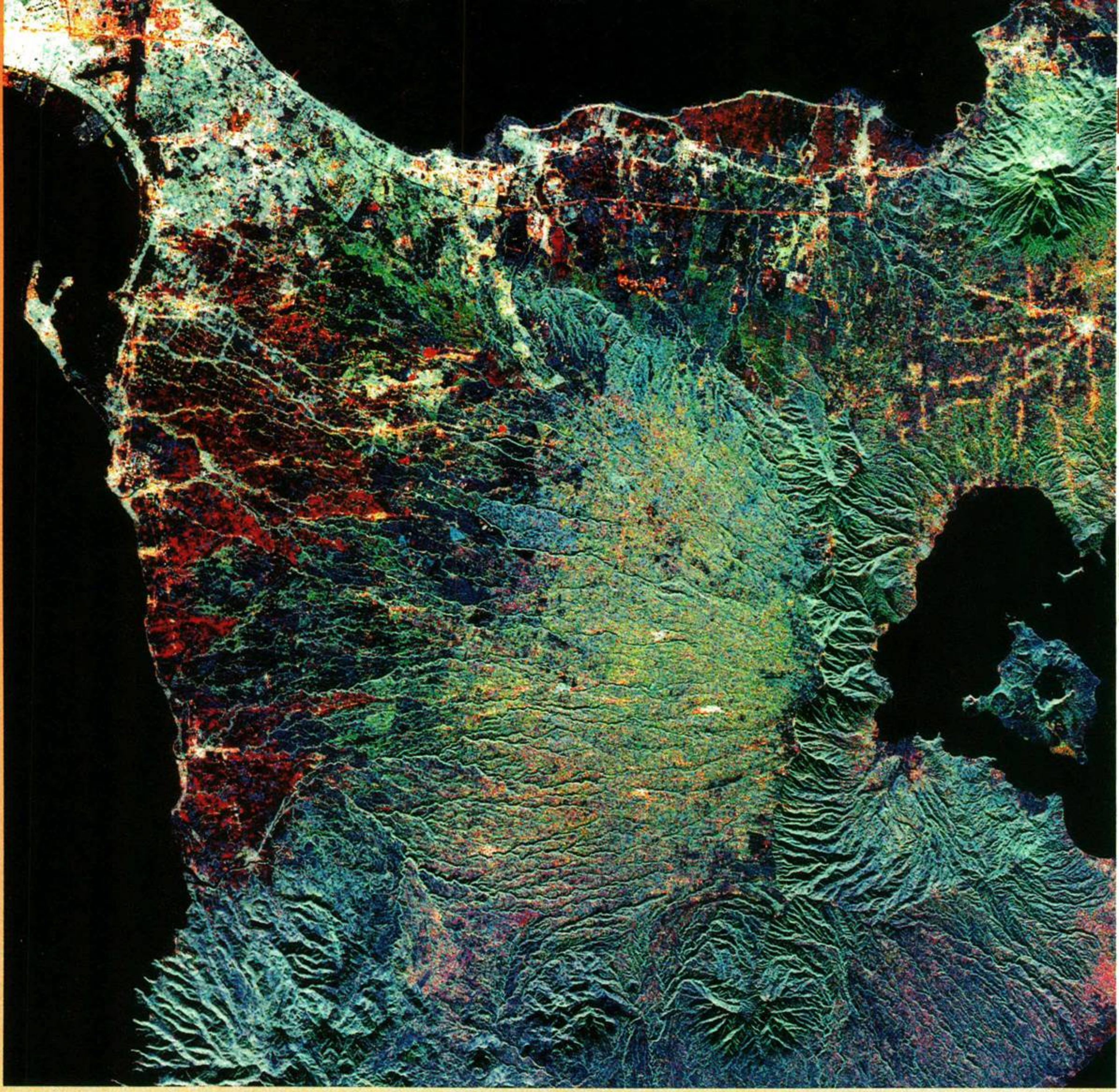
EXTENSION TUBES

1'' long 1¼'' OD thread-in extension ...	**12.00**
2½'' long extension (holds 1¼'' filters) .	**19.50**
4½'' long extension for 1¼'' eyepieces	**$25.00**
3'' long extension for 2'' eyepieces* ..	**$26.00**
2'' long extension for 2'' eyepieces* ..	**$26.00**

VIEWING ADAPTERS

2''/1¼'' reducing bushing,threaded 48mm*	**$25.00**
2''/T-thread adapter, threaded 48mm* ..	**$25.00**
T-thread/1¼'' adapter	**$25.00**
F/10 2'' or 1¼'' eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2'' Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*



Mission to Planet Earth

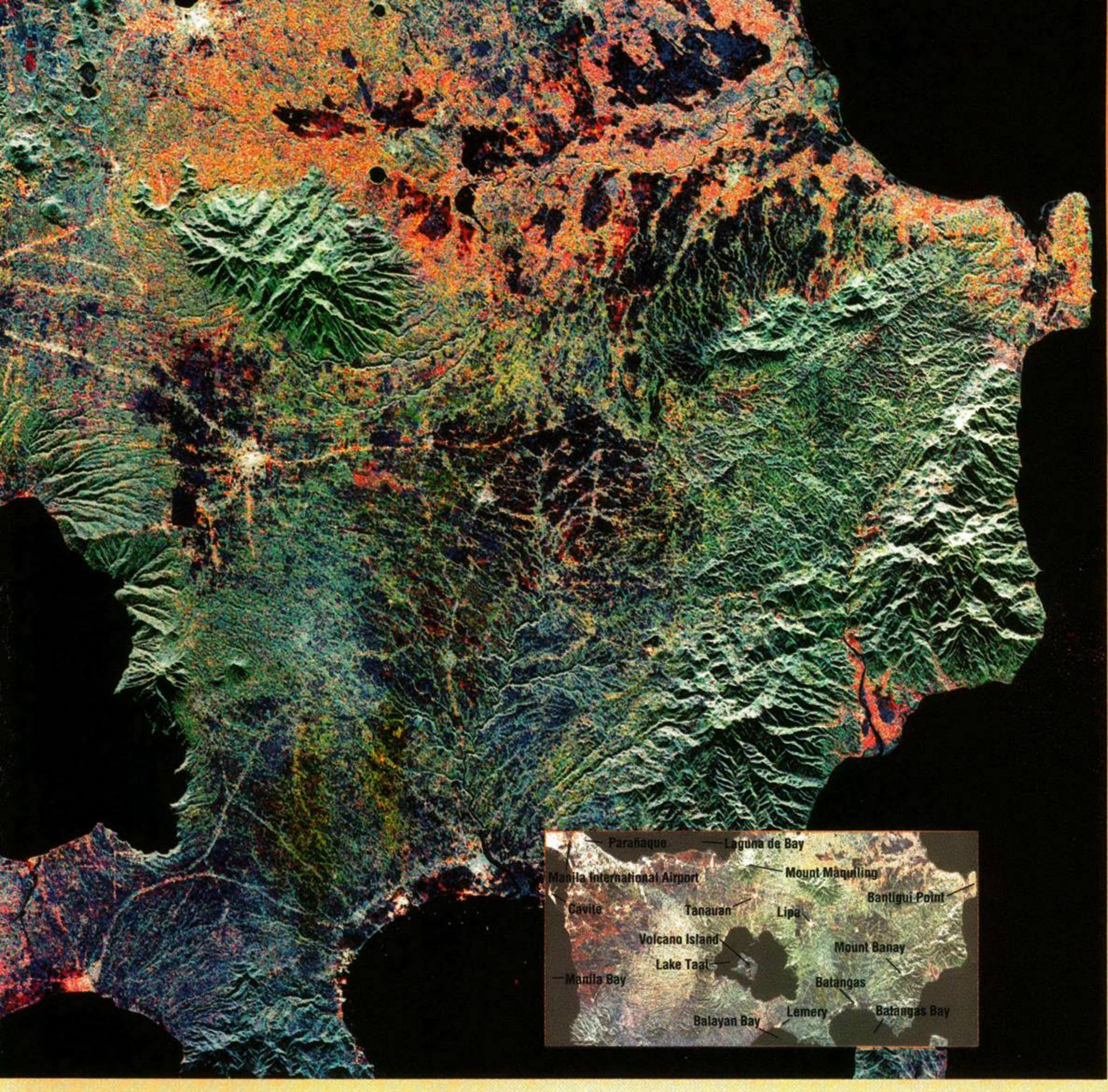
Earth scientists are using imaging radar to study changes in our planet's environment and to monitor volcanos, such as Taal in the Philippines.

by David Bruning

The space shuttle Endeavour carried the Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar into space, 120 miles above Earth's surface, in October 1994. Endeavour's mission included searching for changes in volcanos, forests, wetlands, snow cover, and ocean currents.

Radar has an advantage in that it can record a region regardless of weather and lighting conditions. Endeavour's instruments viewed Earth in swaths, each swath covering a width of 9 to 56 miles depending on the antenna beam used. The smallest details visible in the radar images vary from 33 to 656 feet across.

During its *78th orbit, Endeavour flew* over the island of Luzon in the Philippines. This view taken by SIR-C shows a 34-mile-by-68-mile area from Manila at upper


Parañaque
Laguna de Bay
Manila International Airport
Mount Maquiling
Bantigui Point
Cavite
Tanauan
Lipa
Volcano Island
Lake Taal
Mount Banay
Manila Bay
Batangas
Lemery
Balayan Bay
Batangas Bay

left (north) to Verde Island at lower right (south). The vivid greens, reds, and blues result from combining signals measured by the imager in the L and C radar bands and indicate surface roughness and soil type. (L has a wavelength of 24 centimeters and C a wavelength of 6 cm.) Black marks water and the white dots in Batangas Bay are probably ships.

In the center of the image lies Taal, a simmering volcano whose caldera stretches 18 miles wide. Filled with water, it is now called Lake Taal. Over centuries, erosion has deeply chiseled the hills and cliffs marking the caldera's rim. At the lake's center is Volcano Island, which also has a caldera filled with water.

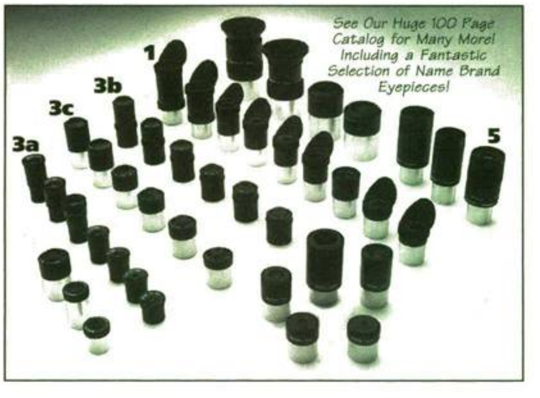
The yellowish patch in the southwest corner of the island is the site of Taal's last eruption. On September 28, 1965, the volcano exploded violently and threw up a column of debris to heights of 10 to 13 miles. This was the 34th eruption of Taal since 1572 (Manila was founded in 1571). Geologists have monitored the volcano since early 1991 to see if new tremors, fumaroles, and fractures foretell an eruption. In fact, geologists were monitoring Taal, anticipating an eruption, when Mount Pinatubo, 90 miles north, erupted instead in June 1991.

Taal is one of 15 volcanos geologists have identified that potentially present a major hazard to nearby populations. Manila lies only 30 miles from Taal, so it bears careful scrutiny, especially considering the destruction caused by Pinatubo. Continued radar imaging from space may provide the clues scientists need to predict when Taal's next eruption will occur. ☐

ORION TELESCOPE CENTER

THE WORLD'S LARGEST CATALOG OF TELESCOPES, BINOCULARS & ACCESSORIES FOR AMATEUR ASTRONOMERS

Eyepieces and Barlows


See Our Huge 100 Page Catalog for Many More! Including a Fantastic Selection of Name Brand Eyepieces!
1
3b
3c
3a
5

1. Orion 5-Element Ultrascopic™ Eyepieces

With Superb, High-Performance Ultra™ Multi-Coatings!

Made for Orion by Japan's finest lens maker, Ultrascopic eyepieces yield the highest contrast, greatest light transmission and best overall image fidelity obtainable. With a superior 5-element design and Ultra™ Multi-Coatings on *every* surface, they achieve a level of performance "name brand" 4-element models can't match. Wide 52° flat field of view. Removable contoured rubber eyeguard. The 5mm and 3.8mm feature advanced 7-element designs which yield surprisingly long eye relief. Absolutely guaranteed to knock your socks off!

Medium-High Power 5-element
20mm #8566, **15mm** #8568, **10mm** #8570, **7.5mm** #8572 ***$89.95 ea.*** (3.45)

Wide Field 5-element
25mm #8564 ***$99.95*** (3.45)
30mm #8562 ***$119*** (3.45)
35mm #8560 ***$139*** (3.45)

***High Power 7-element** —Long Eye Relief*
5mm #8574 ***$109*** (3.45)
3.8mm #8576 ***$104*** (3.45)

5. UltraZoom™ 7–21mm

The finest zoom you can buy for your 1.25" telescope. For astronomy or terrestrial observing. 65°-35° field. Fully coated.

#8556 ***$179*** (3.67)

✧Sirius™ Plössl 1.25" Eyepieces

Fantastic Name-Brand Quality Eyepieces at an Incredible Low Price!

You could pay nearly twice the price for "famous name" Plössl eyepieces, but we don't think you'll be able to tell the difference if you compare them to these fantastic eyepieces! Sirius Plössls are top-quality, 50° apparent field (43° 40mm) eyepieces with extremely sharp images of impressively high contrast. Ideal for all types of telescopes. The Classic 4-element Plössl design is renowned for its fantastic performance and has become the standard by which all other eyepieces are compared. The Fully Magnesium fluoride coated optics are mounted in precision black anodized aluminum housings with chrome-plated brass 1.25" barrels for durability and precision fit.

7.5mm #8738, ***10mm*** #8736, ***17mm*** #8734, ***26mm*** #8732 Reg. $58 ***Sale! $39.95*** (3.45)

40mm #8730 Reg. $80 ***Sale! $59.95*** (3.67)

Custom Field Case #5911 ***$12.95*** (2.19)
(Holds up to 4 eyepieces except for the 40mm)

SALE! $39⁹⁵ EACH! *(7.5mm-26mm)*
($59⁹⁵ 40mm)
Save $18-$20 each–*Any Quantity!*

3. Orion Explorer™ Multi-Coated 1.25" & .965" Eyepieces

These fine quality multi-coated eyepieces offer great performance at Orion's low direct-discount price. Black anodized, internally blackened, threaded for filters (except 40mm .965").

b *1.25" Orthoscopic*
5mm #8500, **7mm** #8502, **9mm** #8504, **12.5mm** #8506, **18mm** #8524, **25mm** #8526
$59.95 each (2.98)

c *1.25" Kellner*
6mm #8536, **9mm** #8538, **12mm** #8540, **18mm** #8508, **25mm** #8510, **40mm** #8512
$49.95 each (2.98)

a *.965 Orthoscopic*
5mm #8580, **7mm** #8581, **9mm** #8582, **12.5mm** #8583 ***$49.95 each*** (2.98)

a *.965 Kellner & Achromatic Huygenien*
K 18mm #8584, **K 25mm** #8585, **AH 40mm** #8586
$37.95 each (2.98)

Illuminated Reticle Eyepieces

12.5mm Plössl Illuminated Reticle 1.25"
Illuminator has fully adjustable brightness. Features double crossline reticle. Batteries included.
#8484 ***$119*** (3.45)

9mm Orthoscopic Illuminated Reticle 1.25"
Adjustable brightness illuminator. "Bull's-eye within crosshairs" reticle. Needs 2 SR-44 batteries, not included.
#8488 ***$129*** (3.67)

12mm Kellner Illuminated Reticle 1.25"
Features double crossline reticle and red LED illuminator. Plugs into power panel drive bases.
#8482 ***$74.95*** (3.45)

12mm Kellner Illuminated Reticle 1.25"
Same as #8482 above except has a wireless illuminator. Needs 2 SR-44 batteries, not included.
#8481 ***$99.95*** (3.45)

Shorty™ Barlows

The short bodies allow extra versatility: provides 2x magnification when the eyepiece is inserted directly and 3x magnification when positioned before the diagonal on a refractor or SC. Will work in all telescopes, including those where longer barlows won't work.

.965" #8710 ***$44.95*** (2.98)
1.25" #8711 ***$54.95*** (3.45)

Barlow Lenses

Orion offers a large selection of barlow lenses, allowing you to double or even triple the power of your eyepieces, maximizing the versatility of your collection. Available in .965", 1.25" and 2" diameters.

Fully Baffled 2x Barlow
Multi-coated, with internal baffling to block transmission of stray light. Premium performance at a remarkable price.
.965" #8740 ***$39.95*** (2.98)
1.25" #8746 ***$46.95*** (2.98)
2" #8724 ***$89.95*** (3.95)

VariPower 2-3x Barlow
Allows you to adjust the magnification factor of the barlow by sliding the internal cell along a calibrated scale. Fully multi-coated optics. 1.25" barrel.
#8748 ***$59.95*** (3.45)

Filters

SkyGlow™ Light Pollution Filters

The finest available, SkyGlow™ filters from Orion make detailed deep-sky observing possible from light polluted city and suburban locations. Sophisticated multi-layer technology actually absorbs light pollution! Greater blocking and higher transmission than competitive models. See catalog for details.

SkyGlow UltraBlock Filters *(Visual Only)*
For severely light polluted areas and faint nebulae.

.965" UltraBlock Filter fits .965" eyepieces.
#5655 ***$79.95*** (2.98)

1.25" UltraBlock Filter fits 1.25" eyepieces.
#5654 ***$99.95*** (3.45)

2" UltraBlock Filter fits 2" eyepieces. #5657
SC UltraBlock Filter fits rear cell of Meade & Celestron SC scopes. #5656 ***$149 ea.*** (3.67)

Glass Solar Filters

High-quality optical glass filters, for superb images of the sun with your telescope. Triple-coated with advanced scratch-resistant stainless steel alloy. Great for both visual and photographic use. Slide fits over the front of your telescope.

For 8" SCs #7713 ***$144*** (4.05)
For 10" SCs #7715 ***$162*** (4.05)

NEW! *Solar glass filters for Deep Space Explorer reflectors. Many other sizes available—see our free catalog for details.*

SkyGlow Broadband Filters
(Photographic & Visual)
For slightly to moderately light polluted areas.

1.25" Broadband Filter fits 1.25" eyepieces.
#5660 ***$79.95*** (3.45)

SC Broadband Filter fits rear cell of Meade & Celestron SC scopes. #5658 ***$99.95*** (3.45)

52mm Broadband Filter For 52mm camera lenses. (Adapter rings available for other diameters.)
#5668 ***$87.50*** (3.45)

2" Broadband Filter fits 2" eyepieces.
#5659 ***$119*** (3.45)

.965" Broadband Filter fits .965" eyepieces.
#5661 ***$49.95*** (2.98)

Moon Filters

Cuts 87% of the light from the Moon. Reduces glare by uniformly reducing light transmitted over the entire spectrum.

.965" #5664, 1.25" #5662 ***$15.95*** (2.43)

Color Eyepiece Filters

Made from absolutely the highest quality photographic-grade precision-ground optical glass, anti-reflection coated. Ideal for contrast-enhancing planetary and lunar observations and photography with any telescope. The black anodized, machined aluminum cells thread into any standard eyepieces, or into our universal camera adapters.

.965" Set of 4 #80A Blue, #58 Green, #25 Red, #15 Yellow. #5510 ***$49.95*** (2.98)

1.25" Basic Set of 4 *#80A Blue, #58 Green, #25 Red, #15 Yellow.* #5514

1.25" Expansion Set of 4 *#21 Orange, #47 Violet, #11 Yellow-Green, #82A Blue.* #5516

1.25" Advanced Set of 4 *#8 Yellow, #23A Red, #38A Blue, #56 Green.* #5570

$54.95 ea. (2.98)

2" Set of 4 Includes #80A Blue, #58 Green, #21 Orange and #12 Yellow. #5513 ***$89.95*** (2.98)

Individual Filters
.965" & 1.25" ***$14.95***; 2" from ***$32.50***

Observing Aids

Eyepiece & Accessory Cases

With patented unbreakable latches, die-cut foam inserts. (Inside Dimensions shown)

Small Case (shown)
11"x7"x3"
#5951 ***$17.95*** (2.78)

Medium Case
12.5"x9"x5" #5952
$26.95 (3.36)

Large Case
16"x11"x5" #5953
$49.95 (5.19)

Orion® FlexiShield™ Dew Caps

Forms into a tube with Velcro closure, opens flat for storage and travel. Models to fit most telescopes.

8" Celestron/Meade SC #4200 ***$44.95*** (2.98)

Other sizes available for scopes 3.5" to 14"—See our catalog for details.

Orion® Dew Zapper

Gently replaces lost heat, a sure-fire cure for dew problems.

8" Dew Zappers—fit all Meade & Celestron 8" SCs
DC #3503, AC #3504 ***$47.95*** (2.98)

10" Dew Zappers—fit all Meade 10" SCs
DC #3506, AC #3508 ***$54.95*** (2.98)

11" Dew Zappers—fit all Celestron 11" SCs
DC #3510, AC #3512 ***$59.95*** (2.98)

Night Vision Flashlights

An essential accessory for astronomers. Choose from our wide selection.

Nitewriter Pen #5709	***$9.95*** (1.79)
Hands-Free Flex Light #5707	***$19.95*** (2.43)
Starlite LED Flashlight #5714	***$24.95*** (2.43)
Celestron LED Flashlight #5720	***$21.95*** (2.43)

Observer's Chairs

Standard Model—Adjustable height center column and padded seat.
#5935 ***$34.95*** (4.70)

Deluxe Model—Built for professional musicians. Extra heavy duty.
#5934 ***$94.50*** (8.02)

Quality Components for Building or Upgrading

Parabolic Primary Mirrors

Excellent hand-figured parabolic mirrors guaranteed to meet theoretical limits of resolution. Fine polished, coated twice: with Aluminum and Silicon monoxide. Very competitively priced! *See catalog for pricing.*

Standard Primary Mirrors
Made from fine soda-lime plate glass, 1:8 thickness ratio. Guaranteed 1/8 wave. Sizes: 6" f/8, 8" f/6, 10" f/5.6, 12.5" f/4.8.

Pyrex Low Expansion Mirrors
Made from fine annealed Pyrex brand low expansion glass, 1:8 thickness ratio. Guaranteed 1/10 wave. Available with standard or 94% reflectivity Enhanced Aluminum coatings. Sizes: 6" f/5, 6" f/8, 8" f/6, 10" f/4.5, 10" f/6, 12.5" f/6.

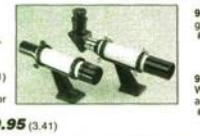
Elliptical Secondary Mirrors

Made from fine annealed Pyrex brand glass, aluminized and SiO overcoated. Guaranteed 1/10 wave accuracy. Available with standard or high reflectivity Enhanced Aluminum coatings. Nine sizes from 1.00 to 4.00" minor axis.
See catalog for pricing.

6x30 Achromatic Finder Scopes

6x30mm—Same unit used on $1000+ "big name" telescopes. With 2-ring metal bracket, fits scopes 6"-12".
#13023 (white) ***$49.95*** (3.41)

6x30mm Right Angle—90° prism for right-angle viewing. Includes bracket.
#13021 (white) ***$79.95*** (3.41)



Large Aperture Finder Scopes

These are higher-quality finders at very reasonable prices! Fully coated wide field achromatic optics with adjustable focus. Precision crosshairs. White or black enameled metal tube. (Mounts sold separately.)

8x50mm—2.7x light grasp of 30mm models. Bright 6.25mm exit pupil.
#7090 (white) #7094 (black) ***$74.95*** (3.41)

8x50mm Illuminated—Wireless illuminator with adjustable brightness.
#7092 (white) #7096 (black) ***$109*** (3.41)

9x60mm — 44% more light grasp than 50mm models.
#7091 (white) #7095 (black)
$109 (3.41)

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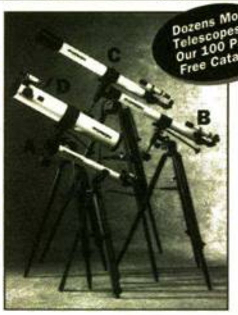

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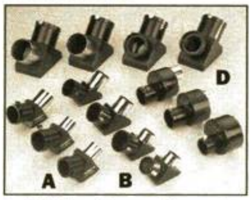

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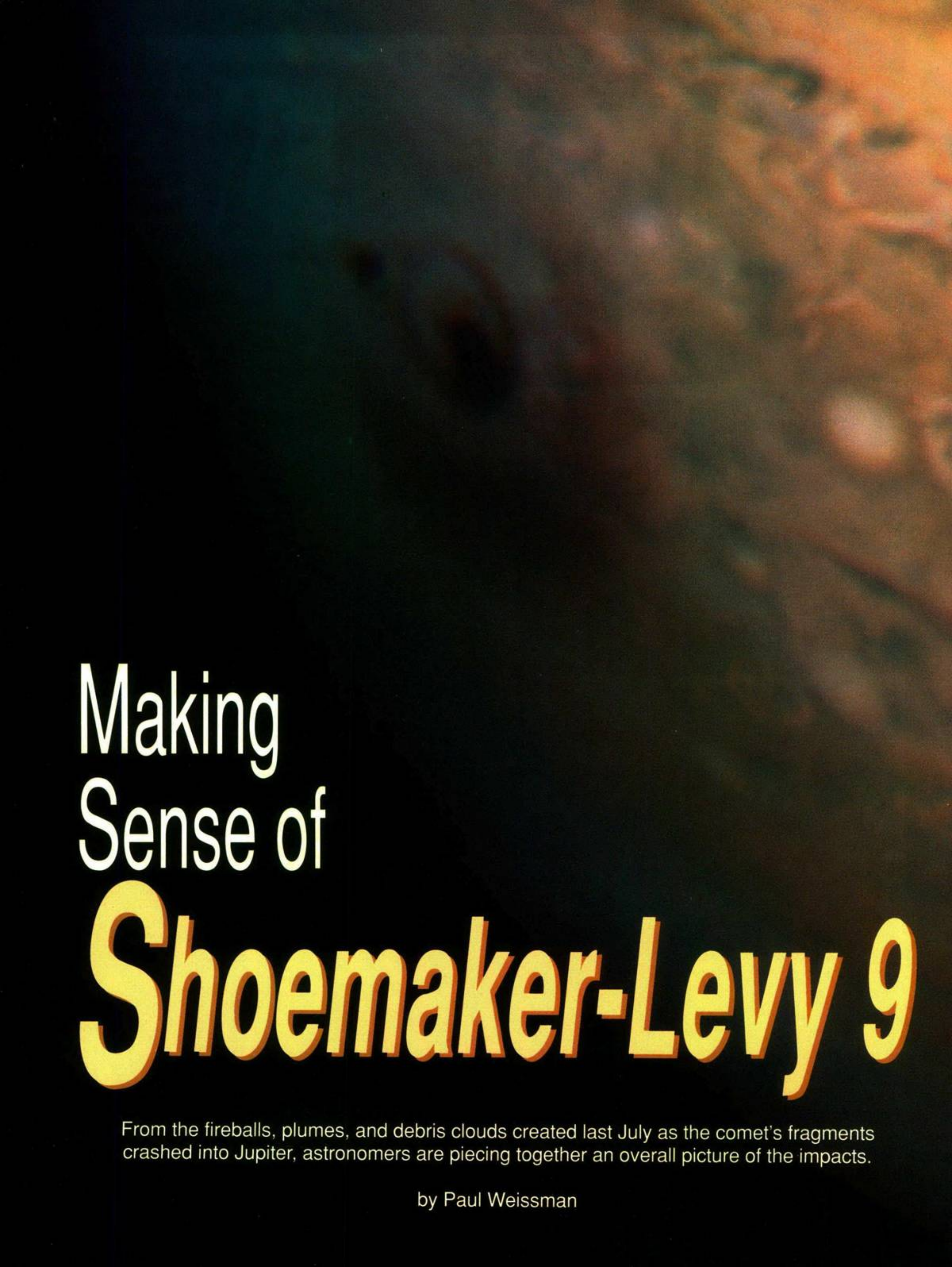


Making Sense of Shoemaker-Levy 9

From the fireballs, plumes, and debris clouds created last July as the comet's fragments crashed into Jupiter, astronomers are piecing together an overall picture of the impacts.

by Paul Weissman

Ten months after fragments of Comet Shoemaker-Levy 9 blasted into Jupiter's southern hemisphere, astronomers remain excited about the huge impacts they observed. The first looks at the huge mountain of data (reported in the October and November issues of ASTRONOMY) tended to focus on individual parts of the impacts, such as the plume of debris thrown up by an impact or the size of the dark cloud that formed above an impact site.

Now past the initial excitement of seeing the impacts, researchers are comparing cloud size and the heights of the plumes and trying to piece together the timings of individual events during each impact. From their data, they hope to learn how big the comet fragments were, how deep the fragments plunged into Jupiter's atmosphere, and what colored the dark clouds seen above the impact sites. This information will tell astronomers a lot not only about the comet itself but about Jupiter's atmosphere and its reaction to the comet strike.

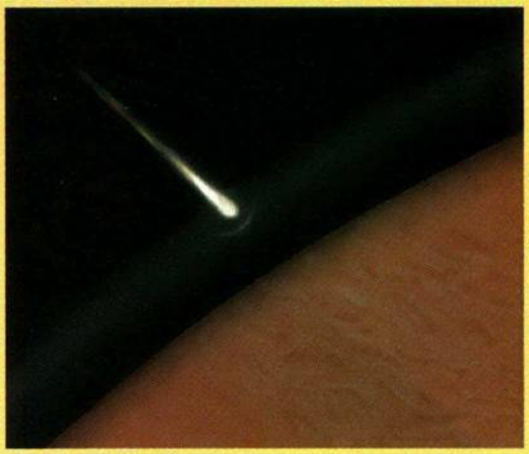
The key to understanding the impacts will likely come from the only observatory that was in position to observe the impacts directly on the night side of Jupiter, the Galileo spacecraft. Galileo is en route to its orbital rendezvous with Jupiter this coming December. It was still 1.6 astronomical units from the planet during the Shoemaker-Levy 9 impacts last July (an astronomical unit is the average distance between Earth and the Sun; Jupiter orbits at 5.2 AU). But Galileo's position ahead of Jupiter in its orbit allowed the spacecraft to see the impact sites that were hidden from Earth-based observers.

Unlike the images and data from ground-based observatories and the Hubble Space Telescope that were available on computer networks almost immediately after the impacts, Galileo's data took many months to get into scientists' hands. Because of the spacecraft's damaged high-gain antenna, Galileo had to store data onboard the spacecraft and trickle it back to Earth at only 10 bits per second. The slow data return rate also meant that scientists could choose only a few impacts to observe because the spacecraft wouldn't be able to store and return data on all events before it closed in on Jupiter and needed to concentrate on that phase of its mission.

The first results returned from Galileo came from the Photopolarimeter-Radiometer, an instrument that measures the brightness of light emitted or reflected by Jupiter's atmosphere. The device observed the B, H, L, and Q fragment impacts: B was a fizzle and produced no visible results, but H and L were both spectacular impacts and Q was easily seen. The details of the flashes detected for each impact provide information about the entry of the fragments into Jupiter's atmosphere.

For the H and L impacts, the Photopolarimeter-Radiometer saw a flash that increased rapidly in intensity to a maximum brightness of about three to five percent of Jupiter's total brightness. The brightness stayed constant for 10

time = 0 seconds



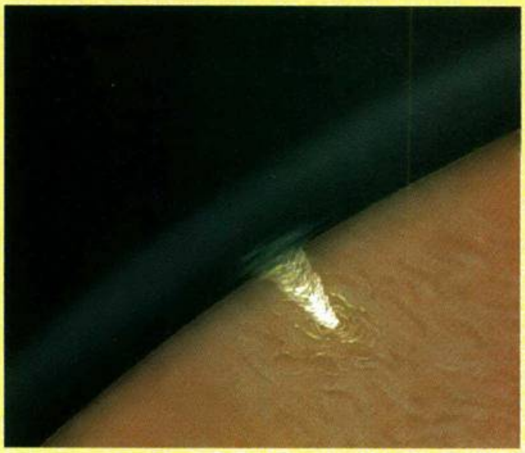
ASTRONOMY: illustrations by Phil Kirchmeier

LIKE A GIANT METEOR, a comet fragment enters Jupiter's atmosphere and starts to vaporize or "burn up." Galileo sees this entry as a flash.

European Southern Observatory

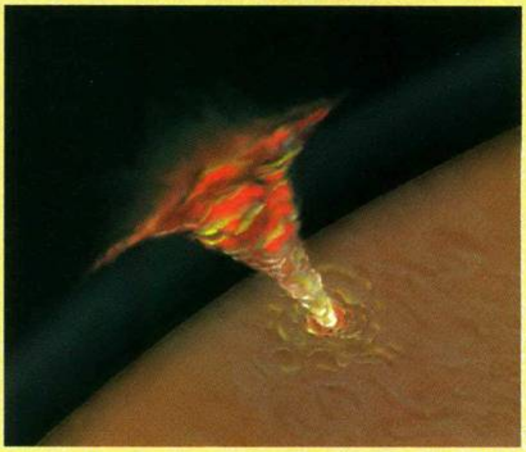
STREAKING TO DOOM on July 16, 1994, the fragments of Comet Shoemaker-Levy 9 lie at about the four o'clock position from the overexposed glare of Jupiter. Jupiter spans only about 1 millimeter in this image.

Heidi Hammel, NASA/HST



t = 5 seconds

IMPACTING THE ATMOSPHERE, the fragment explodes and sends a plume of hot debris upward. Earth-based observers see this second flash and the Hubble Space Telescope sees the plume above Jupiter's limb.



t= 60 seconds

THE PLUME rises 3,300 kilometers above the cloudtops, expanding and cooling as it rises. The fireball reaches 250 km across and has cooled to 500 K. HST still sees the plume but Galileo no longer can.

to 15 seconds and then declined for the next 15 to 20 seconds. The Q event was smaller and briefer, not getting quite as bright initially as H and L and fading fairly rapidly.

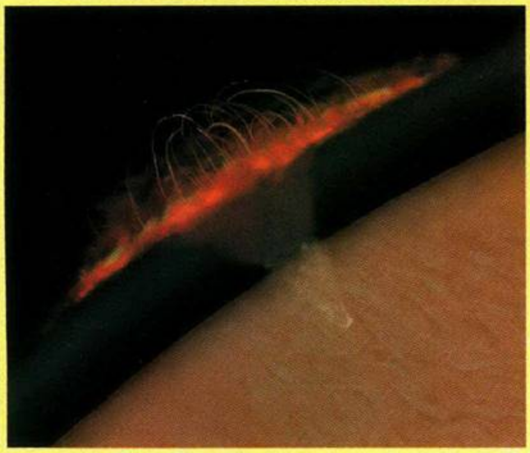
Some Galileo scientists speculate that the flashes occurred as the comet fragments began to burn up like giant meteors as they entered Jupiter's atmosphere. But at a speed of 60 kilometers per second, the comet fragments would have plunged below the Jovian cloud decks in only a few seconds. Why then did the flashes last so long? Other scientists suggest that the Photopolarimeter-Radiometer saw the glowing fireball of superheated gases exploding outward from the impact site. The hot fireball would glow strongly at first and then fade as it expanded and cooled.

In late September, the hot fireball idea got support when Galileo sent back a trio of observations of the large G impact. For this event, the Photopolarimeter-Radiometer took data at the same time as the Near Infrared Mapping Spectrometer and the Ultraviolet Spectrometer. Sure enough, the Photopolarimeter-Radiometer saw the same brightness profile as for H and L, a sharp rise followed by a plateau and then a slow decline, the event lasting a total of about 35 seconds. The Ultraviolet Spectrometer saw the flash too, but just the part corresponding to the sharp rise. Using the brightnesses obtained by the two instruments, Galileo scientists estimate the fireball's diameter was about 10 km and its temperature about 7500 kelvins (the surface of the Sun is only 5800 K).

The Near Infrared Mapping Spectrometer revealed in detail how the fireball grew and cooled, matching predictions by theorists. The instrument first detected the fireball 5 seconds after the Photopolarimeter-Radiometer and Ultraviolet Spectrometer. By that point it had already cooled to about 5000 K. The cloud of gases and cometary debris continued to cool and expand, reaching a diameter of about 250 km and a temperature of about 500 K one minute after the impact (room temper-

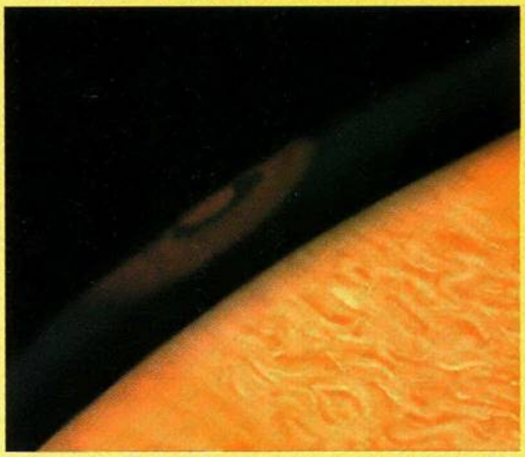
Shoemaker-Levy 9 Facts

- Comet fragments plunged into Jupiter's atmosphere at 60 kilometers per second.
- Galileo saw the hot fireball produced by the plunging fragment.
- Plumes contained a mixture of material from the comet and Jupiter's clouds.
- All the plumes measured by HST rose to a height of 3,300 km.
- The hot spots seen by ground-based infrared telescopes arose from debris in the plumes falling back onto the stratosphere and heating the gas.



t = 10 minutes

DEBRIS FALLING BACK to the stratosphere covers an Earth-sized area. The impact of the debris heats up the gas in the stratosphere, causing the infrared glow observed by Earth-based telescopes.



t = 1 hour

A GIANT BLACK EYE resulted from dark sulfur or carbon compounds in the debris cloud. This cloud of fine particles appeared prominent even through small backyard telescopes for several weeks.

ature is 293 K). The Near Infrared Mapping Spectrometer data also show how the fireball slowly rose through the atmosphere.

The final piece in the flash brightness puzzle came from Galileo's CCD camera, which observed the K and N impacts. For the K impact, also a large one, the camera saw a brightness profile much like that seen by the Photopolarimeter-Radiometer for the G, H, and L impacts. But because of its higher spatial resolution and sensitivity, the camera revealed finer detail in the brightness curve. An initial flash lasting about 5 seconds was followed by a decline in brightness lasting about 10 seconds and then by a re-brightening lasting another 30 seconds before fading out. For the smaller N impact, the camera saw a similar initial 5-second flash, but a much fainter fireball lasting only about 10 seconds following it.

These observations imply that both ideas were right: Galileo apparently saw both the meteorlike flash of a comet fragment entering Jupiter's atmosphere and then the appearance of the fireball from the explosion. The first 5-second flash was the outer layers of the comet fragment beginning to burn up as it plunged into the atmosphere at 60 km/s, heating the air around it to 7500 K or more over a diameter of about 10 km. That superheated atmosphere then exploded immediately into the glowing, boiling fireball that Galileo's instruments continued to observe for almost another minute before it cooled below their detection limits.

A curious fact about the initial meteor flashes seen by the Photopolarimeter-Radiometer and the CCD camera was that they were all about the same brightness, to within a factor of two. This occurred despite the fact that Galileo observed events caused by both large- and moderate-sized impactors. (The B fragment was so small that it fizzled and produced no visible results.) But the fireballs that followed the meteorlike entry events varied considerably in brightness, in closer agreement with what pre-impact models had estimated.

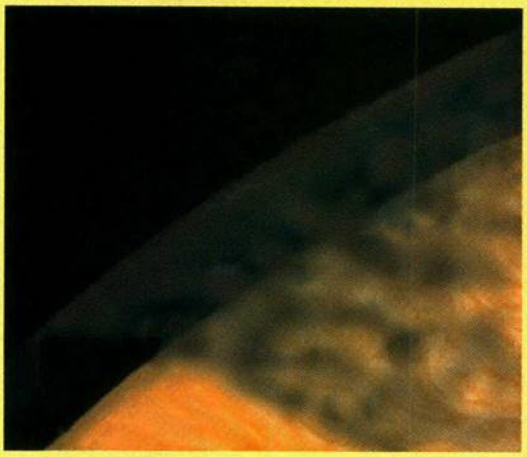
Observations of the impact plumes rising above Jupiter's limb made by the Hubble Space Telescope also produced a mystery. Like Earth-based observers, Hubble could not see the impact sites directly. But within seconds of each impact, Hubble saw plumes of material appearing above the impact sites. These plumes grew and expanded for several minutes and then settled back down onto Jupiter's upper atmosphere. Curiously, all the plumes rose to about the same altitude above the impact sites, about 3,300 km, regardless of the size of the impactor that created them. How did different-sized impactors create similar meteor flashes and similar plume heights, yet different magnitude fireballs and different-sized spots on Jupiter? Finding the answer to that question will keep impact modelers very busy in the coming years.

Another of the important questions still unanswered is, How big were the impacting comet fragments? Estimates for the largest fragments range from 0.5 to 3 km in diameter, a seemingly small range in size. But it means that estimates of a fragment's mass — and its impact energy — vary by a factor of over 200. Perhaps even small fragments could produce spectacular effects by slamming into Jupiter's atmosphere at 60 km/s.

Astronomers who model Comet Shoemaker-Levy 9's close passage by Jupiter in July 1992 that broke the comet into fragments tend to favor smaller sizes, only 0.5- to 1.0-km diameters for the largest fragments. Some astronomers who model the impacts agree. But other impact modelers say that the only way to get the large debris plumes that were observed was to have large impactors. Three sets of observations hint at who may be right.

Impact modelers favoring small impactors thought the comet chunks would have only enough energy to plunge as deep as the ammonia and ammonium hydro-

t = 2 months



PULLED APART BY WINDS in Jupiter's upper atmosphere, the debris in the clouds has spread around the planet. The fine particles may stay suspended in the thin gas for another year before disappearing from view.

sulfide clouds but not the water clouds deeper in Jupiter's atmosphere. The impact would throw comet debris and gas from these clouds high into the atmosphere. Modelers favoring large impactors thought these fragments would have enough energy to penetrate far below the water clouds. The great atmospheric pressure at these depths would swallow up the explosion and bury most of the cometary and Jupiter cloud material deep where it couldn't be seen.

The first piece of evidence suggests the small impactor model is right. Hubble detected large amounts of ammonia and sulfur in the debris clouds, more than could have come from the comet fragments themselves. The impact had to churn up Jupiter's clouds and not completely swallow the effects of the impact.

The second clue was the lack of seismic waves or ripples in Jupiter's atmosphere. Large impactors would excite seismic waves. The failed attempts to detect these waves also supports small impactor models.

The third clue came from Galileo observations. The total energy for each impact, determined from the maximum brightness of the meteor flash and the subsequent fireball (and thus the energy of the fragment streaming through the atmosphere), suggests small fragments hit Jupiter.

Still, Galileo saw only the effects the impacts had on the atmosphere visible above the clouds. If the fragments deposited much of their energy deeper in the atmosphere, the results would have been hidden from view. So although small impactors seem to be favored, astronomers don't yet have a final answer.

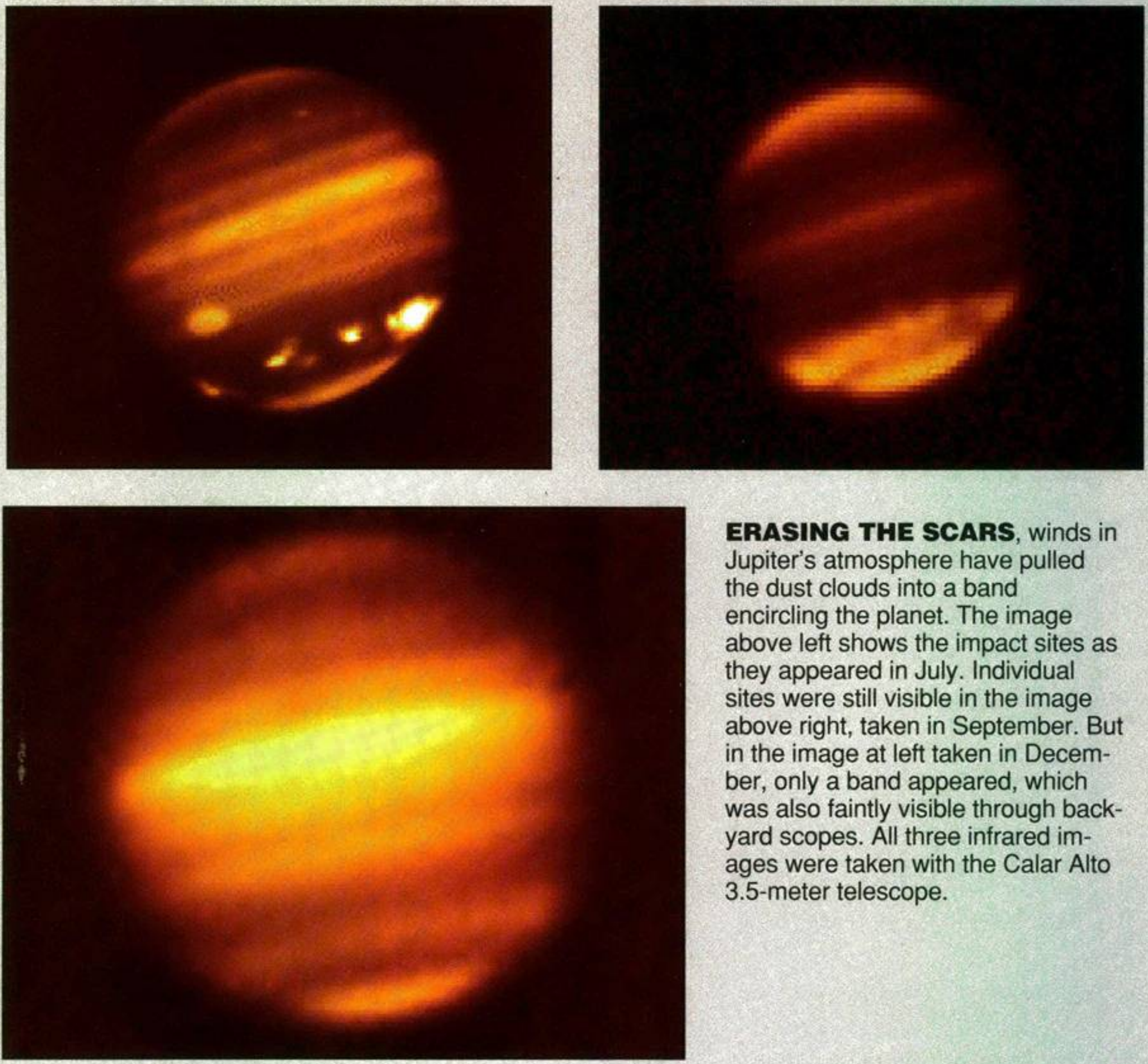
Meanwhile, astronomers are asking what made up the huge clouds of debris that formed in Jupiter's upper atmosphere and why the clouds were so dark. The energy of the impacts was so great that the comet fragments should have vaporized, breaking every molecule down into its constituent atoms. The comet's atoms should have mixed with Jupiter's hydrogen and methane in the superheated fireballs, and new compounds should have rained out of this cosmic stew. Sulfur compounds, which are often dark brown or even black, or carbon compounds from both broken-apart cometary hydrocarbons and Jovian methane would give the clouds a dark color.

Observations made with Hubble, from the ground, and with NASA's Kuiper Airborne Observatory support this picture of a comet-Jupiter mixture's forming the dark clouds. The ammonia and sulfur compounds detected by Hubble most likely came from Jupiter. Kuiper saw huge amounts of water and ground-based observers saw large amounts of carbon monoxide in the plumes that some astronomers suggest could only come from the comet. Thus a mixture of the two sources was likely. But how much of the material came from the comet and how much came from Jupiter's atmosphere is a question that still needs answering.

One thing that is certain is that the dark cloud particles are very fine, only a few micrometers across. Their small size suggests that they may float in Jupiter's atmo-

Unanswered Questions

- What were the diameters of the comet fragments?
- Did the fragments plunge deep into Jupiter's atmosphere or did they barely penetrate the upper cloud layers?
- Did the dark material seen above the impact sites come from the comet or from Jupiter?
- Why did all the plumes rise to the same height but produce different-sized spots?



Images by Tom Herbst, Max-Planck-Institut für Astronomie, et al.

ERASING THE SCARS, winds in Jupiter's atmosphere have pulled the dust clouds into a band encircling the planet. The image above left shows the impact sites as they appeared in July. Individual sites were still visible in the image above right, taken in September. But in the image at left taken in December, only a band appeared, which was also faintly visible through backyard scopes. All three infrared images were taken with the Calar Alto 3.5-meter telescope.

sphere for up to a year after the impacts.

All the debris was blasted out of the impact sites at 10 to 15 km/s, creating the huge plumes seen by Hubble. This ejecta rose up and then fell back, spreading out over an area Earth-sized or larger on Jupiter's stratosphere. When the debris struck the atmosphere it created heat that Earth-based observers saw as immense brightenings in the infrared as each impact site rotated into view. The Near Infrared Mapping Spectrometer observed this heating for the G and R impacts. The heating started about six minutes after the initial impact and continued to grow in area for the next several minutes.

Observers have tracked the debris clouds for many months now since the impacts, watching them spread and merge as Jupiter's winds carry the debris completely around the planet. So Shoemaker-Levy 9 has provided a bonus: the ability to use the debris clouds to study upper-atmospheric winds and the circulation in Jupiter's atmosphere.

One impact is still to come on Jupiter. That will be when Galileo's atmospheric probe plunges into Jupiter on December 7, 1995. The probe will target a region near the planet's equator, and its instruments will provide valuable data on the composition and structure of Jupiter's atmosphere and on the altitudes of the different cloud decks. Theorists will use that data to construct more accurate simulations of exactly what happened when the Shoemaker-Levy 9 fragments struck Jupiter.

Meanwhile, the tale of Comet Shoemaker-Levy 9 remains an ongoing saga. Astronomers already know, however, that the ending of this tale is a happy one. As they try to make sense of the impacts, new ideas about comets and Jupiter's atmosphere have arisen from data about the comet's debris and the debris of discarded models. Simple ideas imagined last July are being replaced by stronger, more coherent theories that explain the entire impact sequence. The debate promises to remain interesting as researchers determine how big the fragments were and how deep they plunged. □

Paul Weissman is a planetary scientist at the Jet Propulsion Laboratory in Pasadena, California. He studied the comet crash using Galileo observations.

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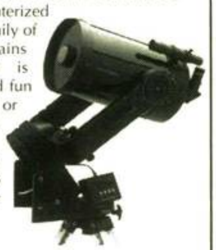

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SKY ALMANAC

Highlights
by Jeff Kanipe

Date	Event
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All month:

First Views: Premier Meteor Shower . . . . . . *(p. 56)*

Observer's Challenge: Finding Pluto . . *(p. 62)*

Ceres Swings Through Leo. . . . . *(p. 65)*

The Starry Sky: Libra . . . . *(p. 63)*

Fire up your telescope for a Pluto search and then glimpse Saturn's disappearing rings. For the unaided eye, there's a meteor shower in Aquarius and a duet between Mars and Regulus.

by Deborah Byrd

Early May's clear, brisk evenings offer you a chance to join an exclusive club made up of those who've seen **Mercury**. Relatively few people ever knowingly see this planet because it seldom strays far from the Sun in our sky. When it does, it's visible for only a short time.

To find fleet-footed Hermes (the Greek name for Mercury), veteran Mercury watchers often use a nearby star or crescent Moon as a guide. Look for such a signpost on the evening of May 1, when a very young Moon hangs in the west during evening twilight, sandwiched between Taurus' bright star Aldebaran and Mercury, which lies about 8° below and to the right of the Moon. If this is your first time tracking down the planet, its brightness for being such an elusive object, magnitude -0.8, may surprise you.

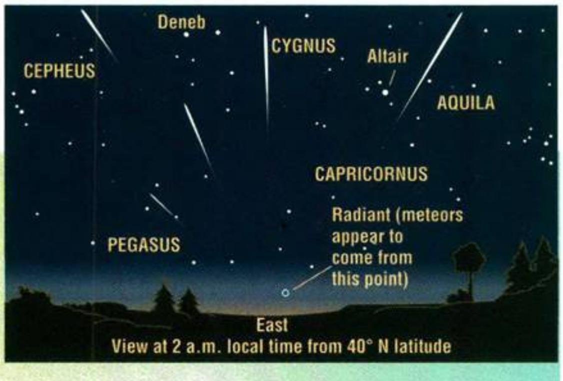
While enjoying this conjunction on May 1, note the relative positions of Aldebaran and Mercury. They begin the month more or less side by side. By keeping tabs on them each night, it's easy to see how much Mercury moves against the star background while Aldebaran slips deeper into the Sun's glare. By May 11, Mercury's time of greatest elongation (when it is farthest from the Sun), the planet lies about 8° above and to the right of Aldebaran.

At greatest elongation Mercury shines at magnitude 0.3 and appears telescopically as an 8"-diameter disk slightly less than half illuminated. Because it passes between Earth and the Sun in early June, Mercury is turning its dark unlit half more and more toward us during the month. By the last week of May, when Mercury becomes exceedingly difficult to see in the Sun's glare, a telescope turned on the planet reveals a slender crescent.

It doesn't take a telescope to witness the travels of another celestial crescent. Each spring there are many evenings when the young crescent Moon appears framed by a collection of bright stars known as the Winter Circle. The Winter Circle is not a constellation but an asterism, a collection of stars that form a noticeable pattern. The Winter Circle contains some of the brightest stars belonging to several well-known constellations (see March's Almanac), all of which are now about to disappear in the west.

Look for a young crescent Moon in the midst of these departing stars between May 2 and 4. If you've never followed a crescent Moon

First Views:
Spring's Premier Meteor Shower



View at 2 a.m. local time from 40° N latitude

One of the best meteor showers this spring emanates from around a 4th-magnitude star in Aquarius that sits practically on top of the celestial equator: Eta (η). The Eta Aquarids, as they are commonly known, have a theoretical rate of 30 per hour. Because of the shallow angle incoming meteoroids make with Earth's atmosphere, Eta Aquarids are noted for their bright fireballs with long paths.

Eta Aquarids first appear around April 21, peak about May 3, and taper off until May 12. This year, the peak occurs May 3 at 23h UT, or 7 p.m. EDT, when the radiant is on the other side of the sky for observers in the Western Hemisphere. Still, the Eta Aquarids have a broad peak, which ensures that the shower remains active a day or so before and after the peak. And since the Moon is only a few days after new, it won't pose a problem.

The shower, which comes from material blown off periodic Comet Halley, was first recorded by Chinese astronomers in A.D.401. Aquarius also hosts two other showers every year: the southern Delta Aquarids, around July 28, which produce about 20 meteors per hour, and the Northern Delta Aquarids of August 12, about 8 to 10 meteors per hour. — *Jeff Kanipe*

1995
MAY

1 The Moon passes 4° south of Mercury, 1 a.m. EDT

2 The Moon is at apogee (252,231 miles from Earth), 8:48 p.m. EDT

7 First Quarter Moon is at 5:44 p.m. EDT

8 The Moon passes 7° south of Mars, 10 a.m. EDT

11 Mercury is at greatest eastern elongation, 10 p.m. EDT (p. 61)

12 The Moon passes 1.0° north of Spica, 4 p.m. EDT

14 Full Moon is at 4:48 p.m. EDT

15 The Moon is at perigee (222,476 miles from Earth), 11:17 a.m. EDT
The Moon passes 2° north of Jupiter, 10 p.m. EDT

19 The Moon passes 6° north of Uranus, 6 a.m. EDT

20 Pluto is at opposition, 1 p.m. EDT (p. 62)

21 Last Quarter Moon is at 7:36 a.m. EDT

22 Earth passes through Saturn's ring-plane, 4 a.m. EDT (p. 64)

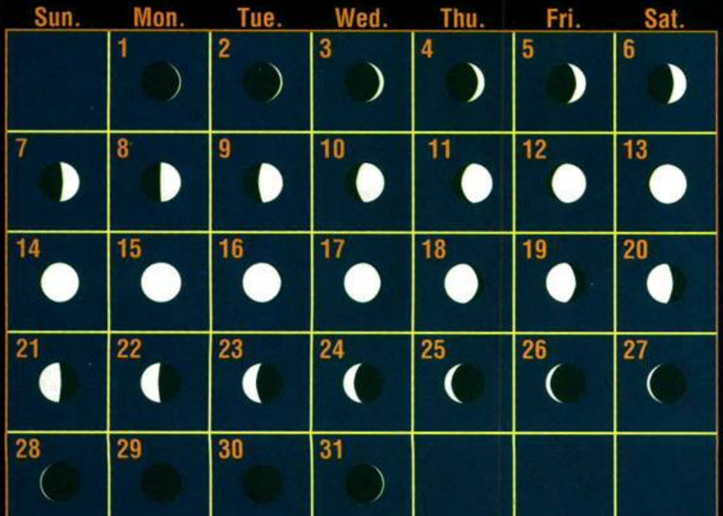
23 The Moon passes 6° north of Saturn, 7 a.m. EDT

24 Mars passes 1.1° north of Regulus, 3 a.m. EDT (p. 64)

27 The Moon passes 0.8° north of Venus, 3 a.m. EDT (p. 61)

29 New Moon is at 5:27 a.m. EDT

30 The Moon is at apogee (252,597 miles from Earth), 3:47 a.m. EDT


Sun.
Mon.
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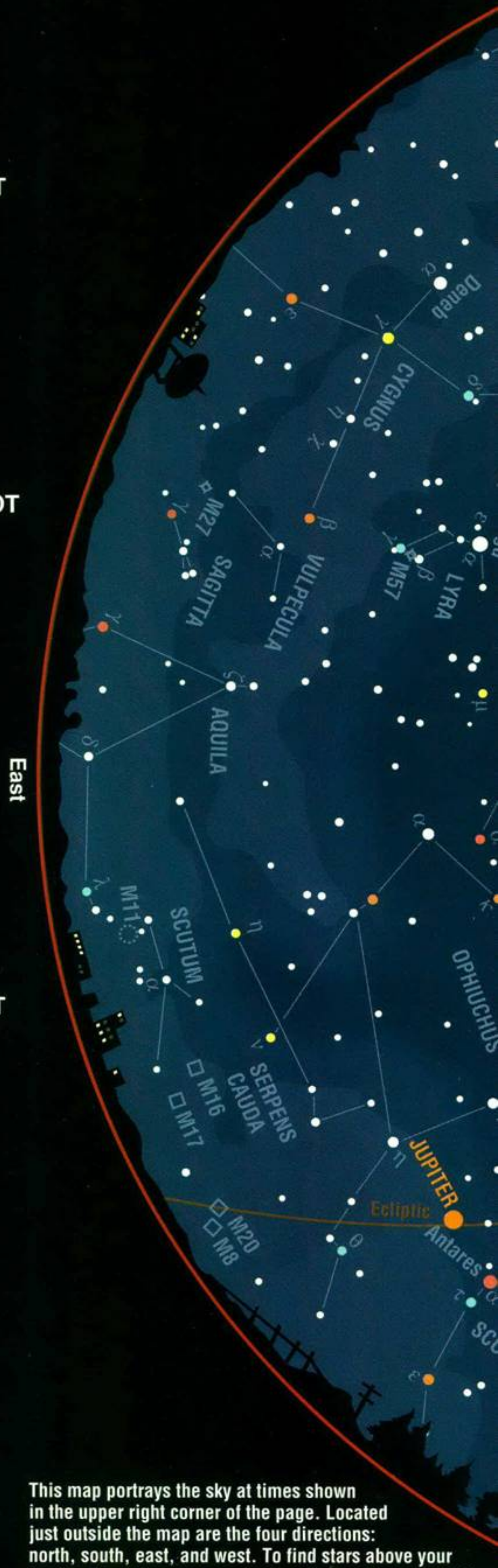
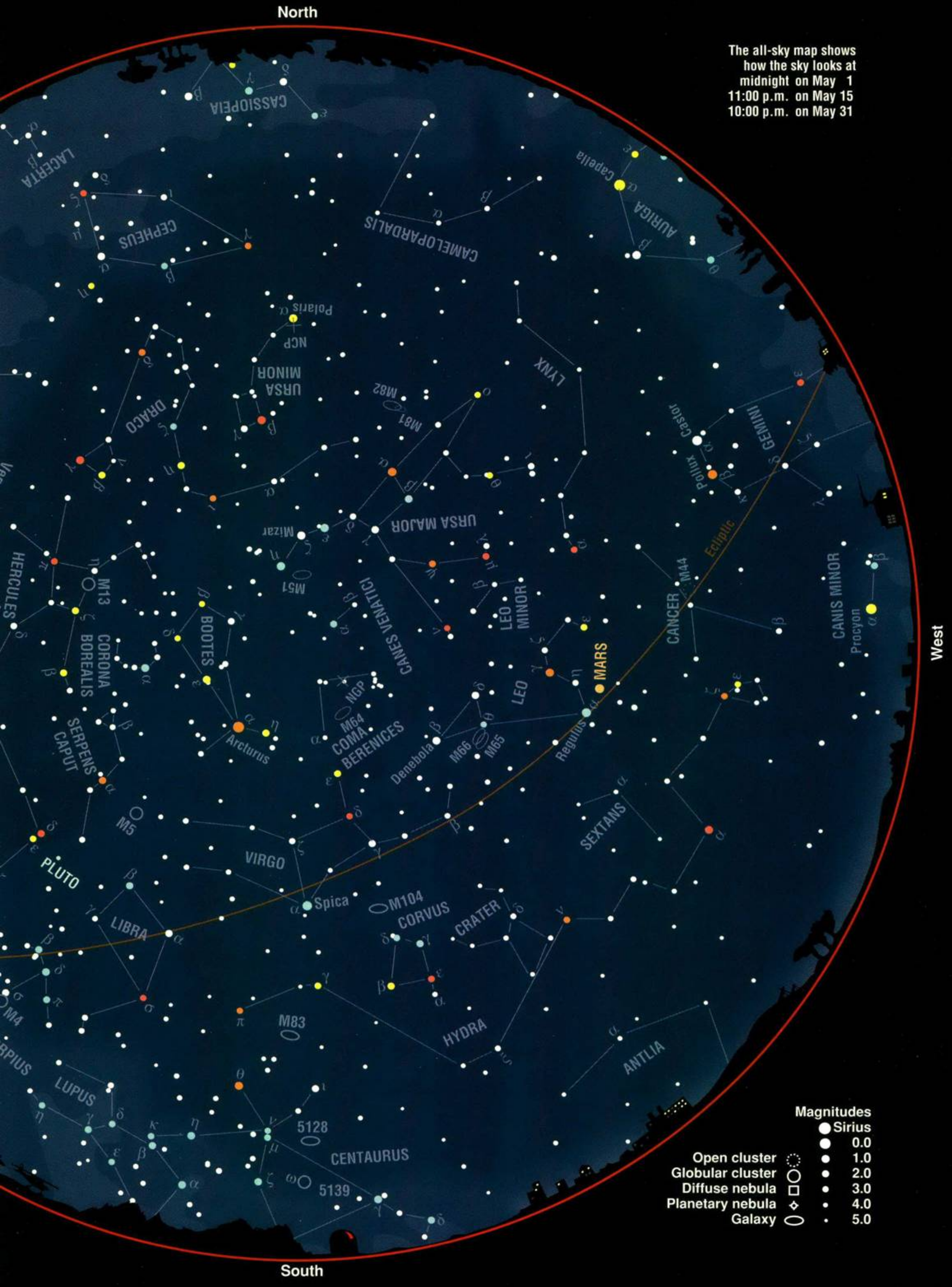

East
Deneb
CYGNUS
LYRA
M57
VULPECULA
M27
SAGITTA
AQUILA
OPHIUCHUS
M11
SCUTUM
SERPENS
CAUDA
M16
M17
JUPITER
Ecliptic
Antares
M20
M8

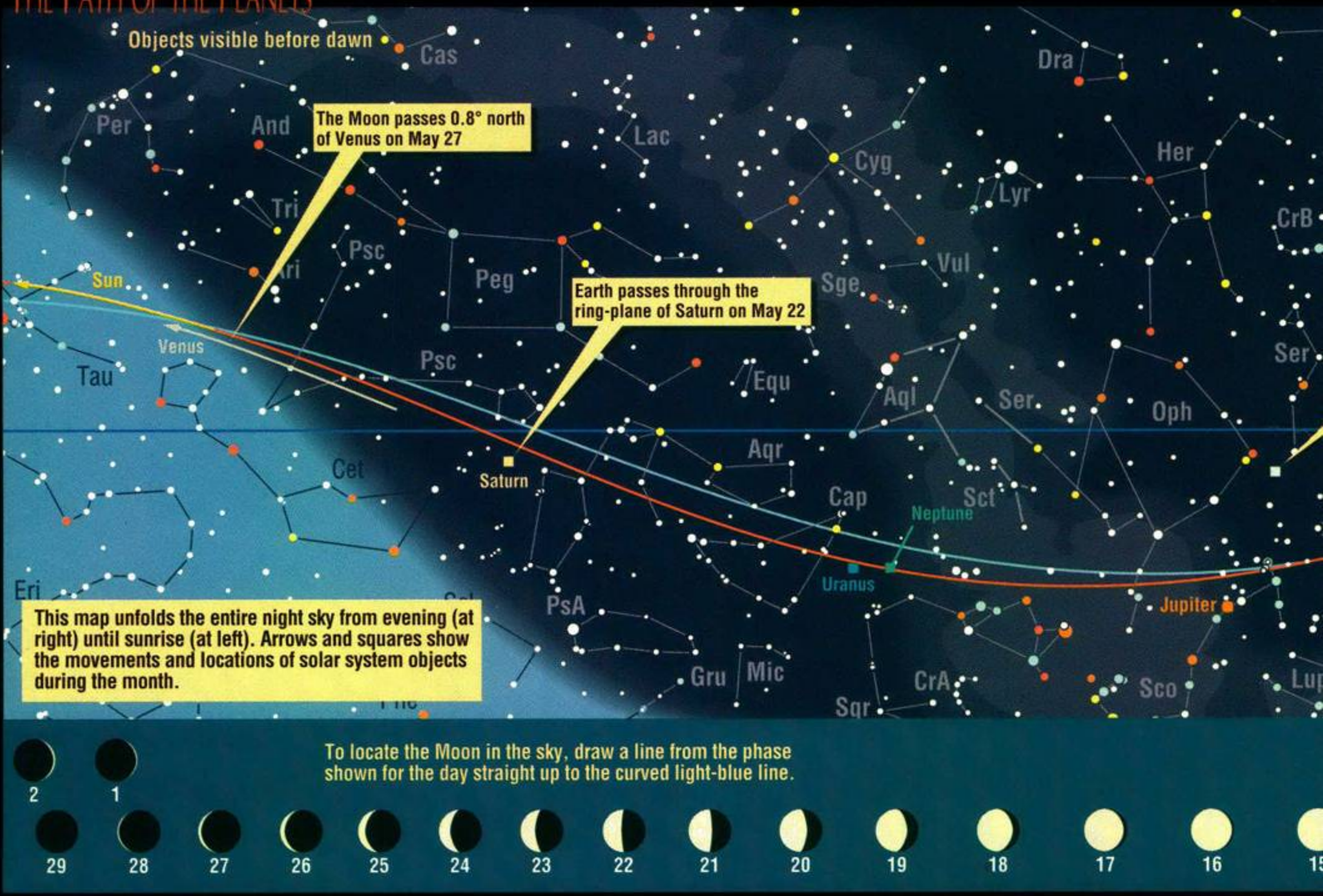
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



The all-sky map shows
how the sky looks at
midnight on May 1
11:00 p.m. on May 15
10:00 p.m. on May 31

North
South
West
CASSIOPEIA
LACERTA
CEPHEUS
CAMELOPARDALIS
Capella
AURIGA
Polaris
NCP
URSA MINOR
DRACO
M82
M81
LYNX
Castor
Pollux
GEMINI
Mizar
URSA MAJOR
M51
HERCULES
M13
CORONA BOREALIS
BOOTES
CANES VENATICI
LEO MINOR
Ecliptic
M44
CANCER
CANIS MINOR
Procyon
MARS
LEO
NGP
M64
COMA BERENICES
Arcturus
SERPENS CAPUT
Denebola
M66
M65
Regulus
M5
SEXTANS
VIRGO
PLUTO
Spica
M104
CORVUS
CRATER
LIBRA
M4
M83
HYDRA
ANTLIA
SCORPIUS
LUPUS
5128
CENTAURUS
ω
5139
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS

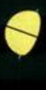
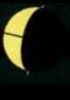
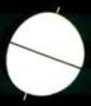
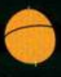
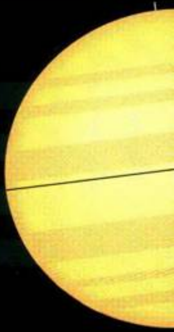

Objects visible before dawn
Cas
Dra
Per
And
Lac
Cyg
Lyr
Her
CrB
Tri
Ari
Psc
Peg
Vul
Sge
Sun
Venus
Tau
Psc
Equ
Aql
Ser
Ser
Oph
Cet
Saturn
Aqr
Cap
Sct
Neptune
Uranus
Eri
PsA
Jupiter
Gru
Mic
CrA
Sco
Lup
Sqr
2
1
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15

The Moon passes 0.8° north of Venus on May 27

Earth passes through the ring-plane of Saturn on May 22

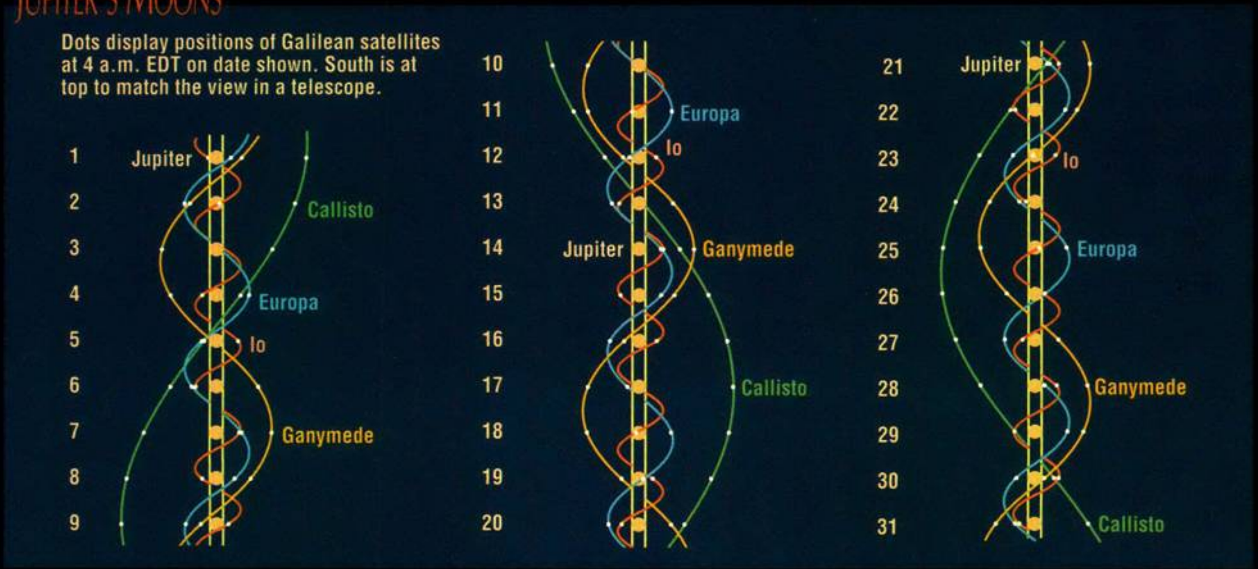
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

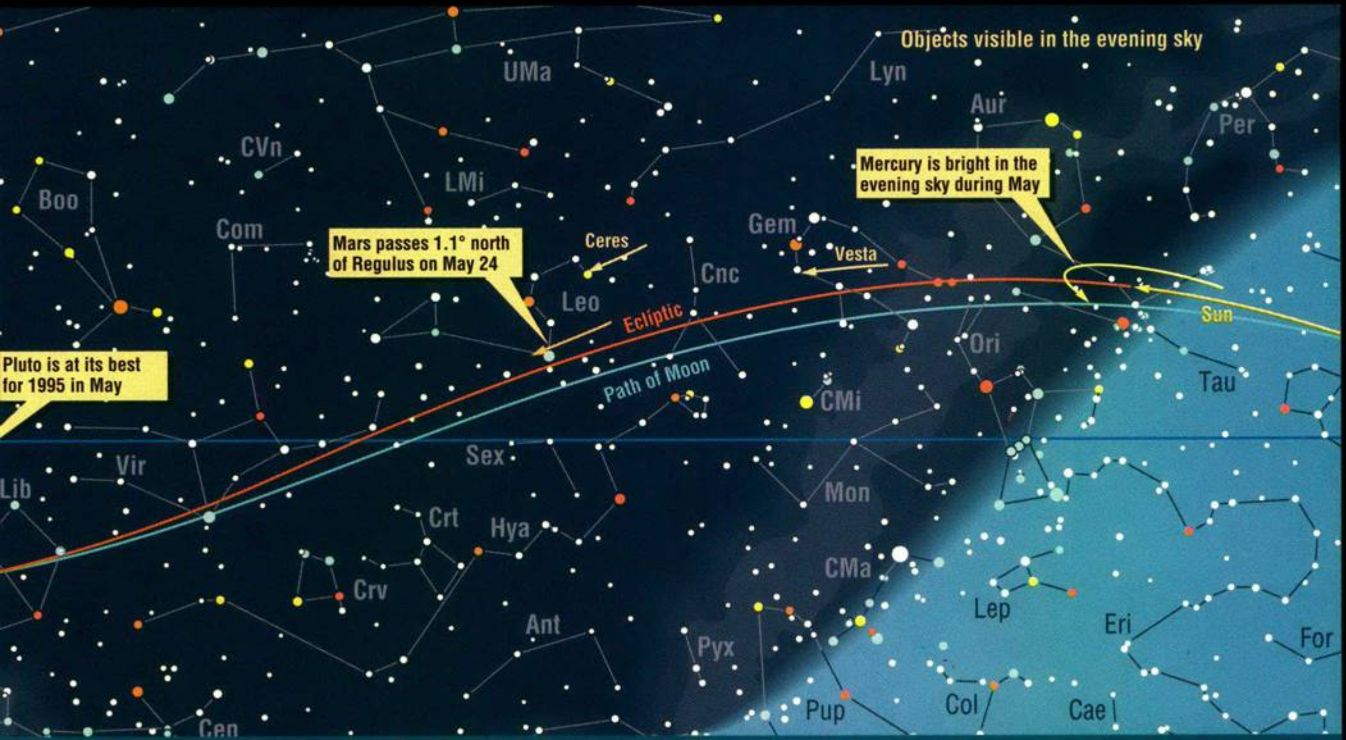






PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	May 1	May 15	May 15	May 15	May 15
Magnitude	–0.8	0.8	–3.9	0.7	–2.5
Angular Size	6.2"	8.6"	11.3"	7.4"	45.0"
Illumination	70%	30%	90%	89%	100%
Distance (AU) from Earth	1.092	0.779	1.482	1.271	4.378
Distance (AU) from Sun	0.325	0.401	0.727	1.647	5.344
Right Ascension (2000.0)	3h38.2m	4h53.4m	1h45.2m	9h53.4m	16h45.5m
Declination (2000.0)	21°31'	24°51'	9°06'	14°40'	–21°30'

JUPITER'S MOONS



Dots display positions of Galilean satellites at 4 a.m. EDT on date shown. South is at top to match the view in a telescope.

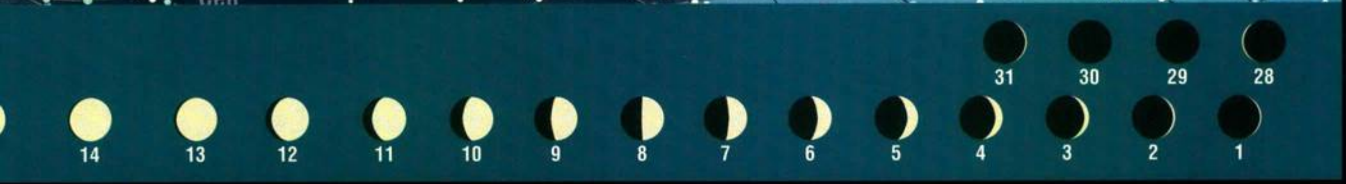

UMa
Lyn
Aur
Per
CVn
LMi
Boo
Com
Gem
Ceres
Vesta
Cnc
Leo
Ecliptic
Sun
Ori
Tau
Path of Moon
CMi
Sex
Vir
Lib
Mon
Crt
Hya
CMa
Crv
Lep
Eri
For
Ant
Pyx
Pup
Col
Cae
Cen

Objects visible in the evening sky

Mercury is bright in the evening sky during May

Mars passes 1.1° north of Regulus on May 24

Pluto is at its best for 1995 in May


31
30
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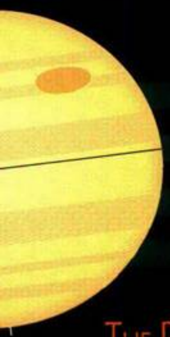
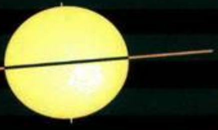
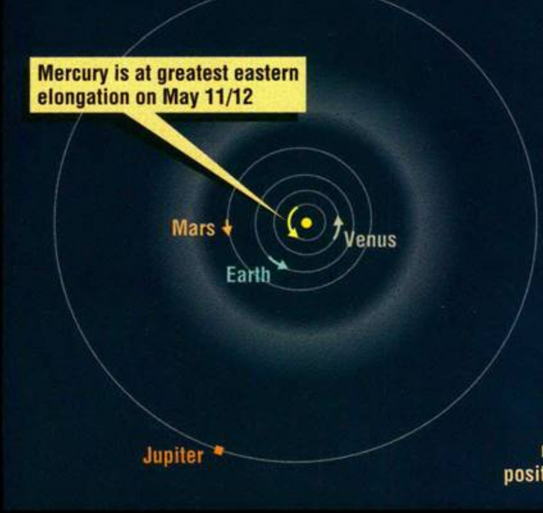
1



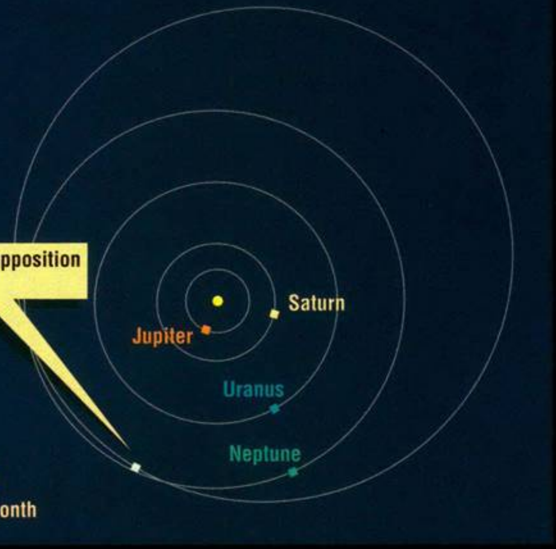


SATURN	SATURN	URANUS	NEPTUNE	PLUTO
May 1	May 31	May 15	May 15	May 15
1.3	1.2	5.7	7.9	13.7
16.1"	16.8"	3.6"	2.3"	0.1"
100%	100%	100%	100%	100%
10.281	9.844	19.290	29.679	28.858
9.648	9.639	19.712	30.171	29.836
23h31.4m	23h40.1m	20h11.3m	19h49.6m	16h00.9m
–5°07'	–4°18'	–20°35'	–20°29'	–6°23'

THE PLANETS IN THEIR ORBITS


Mars
Venus
Earth
Jupiter

Mercury is at greatest eastern elongation on May 11/12


Saturn
Jupiter
Uranus
Neptune

Pluto is at opposition on May 20

Arrows and dots represent planets' positions during the month through these constellations, give it a try. You'll find the view exceedingly striking.

Another celestial march, albeit slower, continues around sunset this month in the southern sky, where the red planet **Mars** is creeping slowly between the eastern and western horizons. As the Sun sets in early May, Mars is halfway between these two horizons, high in the south on the meridian. All celestial objects appear to travel from east to west each day as Earth spins beneath the sky. But the relentless westward march of the constellations, caused by Earth's motion around the Sun, makes the Red Planet appear each evening in a slightly more westerly location. With each passing day, Mars sets earlier in the west.

Mars still appears in the constellation Leo the Lion during May, not far from Leo's brightest star Regulus, drawing to within 1.1° north of Regulus on May 24. The Moon sweeps past the planet on the evening of May 7.

All month Mars falls behind us in its race with Earth around the Sun, fading noticeably in brightness from magnitude 0.4 to 0.9. Through a telescope, the planet appears as a 7"-diameter reddish disk.

An hour after sunset, another planet rises in the east, but this planet is about a thousand times too faint to see with the eye alone. It is **Pluto**, which reaches opposition on May 20. It begins rising at sunset a week or so before opposition, around May 9. Because it's in the sky all night, you'll have plenty of time to search for it with your telescope (see "Without a Doubt, Find Pluto" on page 62).

Pluto now resides inside Neptune's orbit and won't become the outermost planet until February 11, 1999. Sophisticated orbital models cannot pin down the event's exact time because Pluto was only discovered in 1930. Its 248-year orbit around the Sun is not known with the same precision as the orbits of some of the other planets.

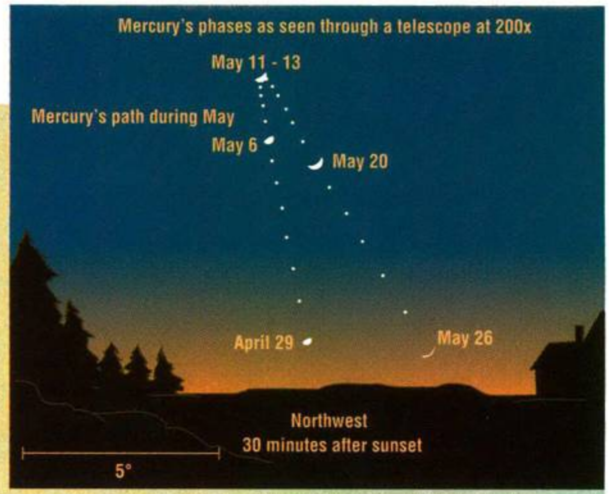
A few hours after sunset,

Your Best Chance to See Mercury

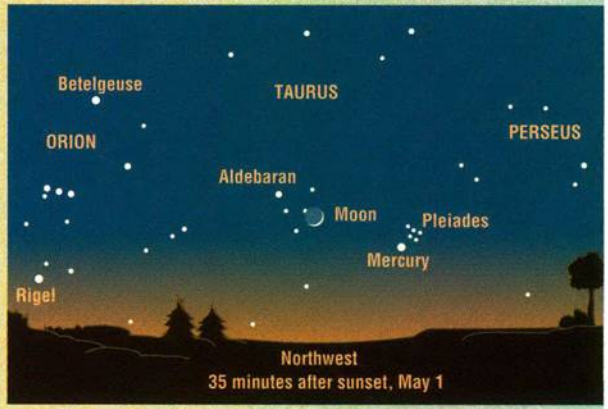
Mercury never strays far from the Sun, which is why observing it can be such a challenge. You usually have a narrow window of opportunity in the bright twilight just before sunrise or after sunset, depending on if it is west or east of the Sun.

This month, your best opportunity occurs May 11 in the west-northwest an hour or so after sunset, which is when Mercury reaches its greatest angular distance from the Sun. To see it, be sure your horizon to the west is flat and unobstructed and begin scanning the region using binoculars or a low-power telescope as soon as the first stars appear in the twilight sky.

On the evening of the 11th, Mercury lies 22° east of the Sun. At 9 p.m., it will be a little over 10° above the northwestern horizon, about 8° above and to the right of Aldebaran in Taurus. Ten days earlier, on May 1, Mercury lies 8° below and to the right of the crescent Moon in the western evening sky. — *Jeff Kanipe*

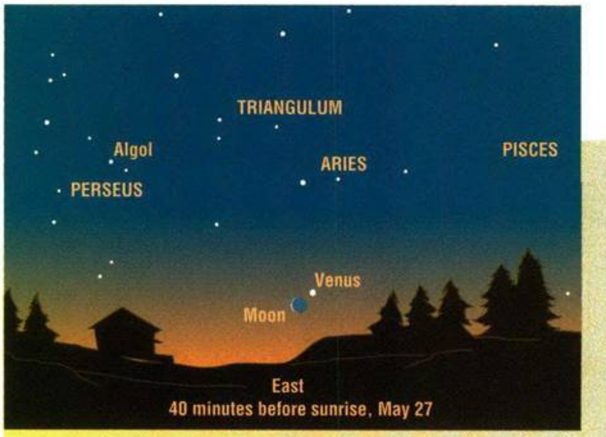

Mercury's phases as seen through a telescope at 200x
May 11 - 13
Mercury's path during May
May 6
May 20
April 29
May 26
5°

Northwest
30 minutes after sunset



Northwest
35 minutes after sunset, May 1

Venus and the Moon Grace the Morning Sky



East
40 minutes before sunrise, May 27

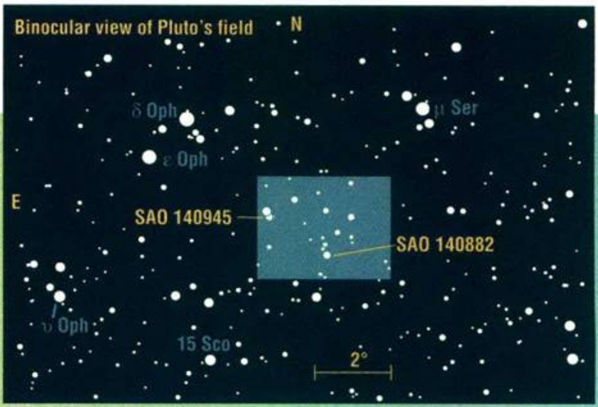
Early risers will discover a nice pairing on the morning of May 27, when brilliant Venus lies a little over 2 degrees to the upper right of the crescent Moon. The two bodies form a line that points directly to the Sun some 19 degrees farther northeast, below the eastern horizon. Such a conjunction is worth capturing on film.

Get out your camera and snap a shot or two using ISO 100 speed film. Mount your camera on a tripod and attach a shutter-release cable. A 100mm lens gives you a nice wide area of sky in which to experiment with composition while also showing the lunar phase.

Open the lens to f/4 and make exposures around ½ second. You want to record the Moon and Venus, but you also want to pick up the twilight colors, which are many and subtle. A ½-second exposure shows the Moon and Venus in a purple sky; longer exposures will show more sky colors, but rapidly over-expose Venus and the Moon. Dust, haze, and high clouds will also affect results. The best advice is to try a range of exposures. Stopping down one f-stop and lengthening your exposure time increases the picture's sharpness. — *Jeff Kanipe*

Observer's Challenge:

Without a Doubt, Find Pluto


Binocular view of Pluto's field
N
δ Oph
ε Oph
μ Ser
E
SAO 140945
SAO 140882
υ Oph
15 Sco
2°

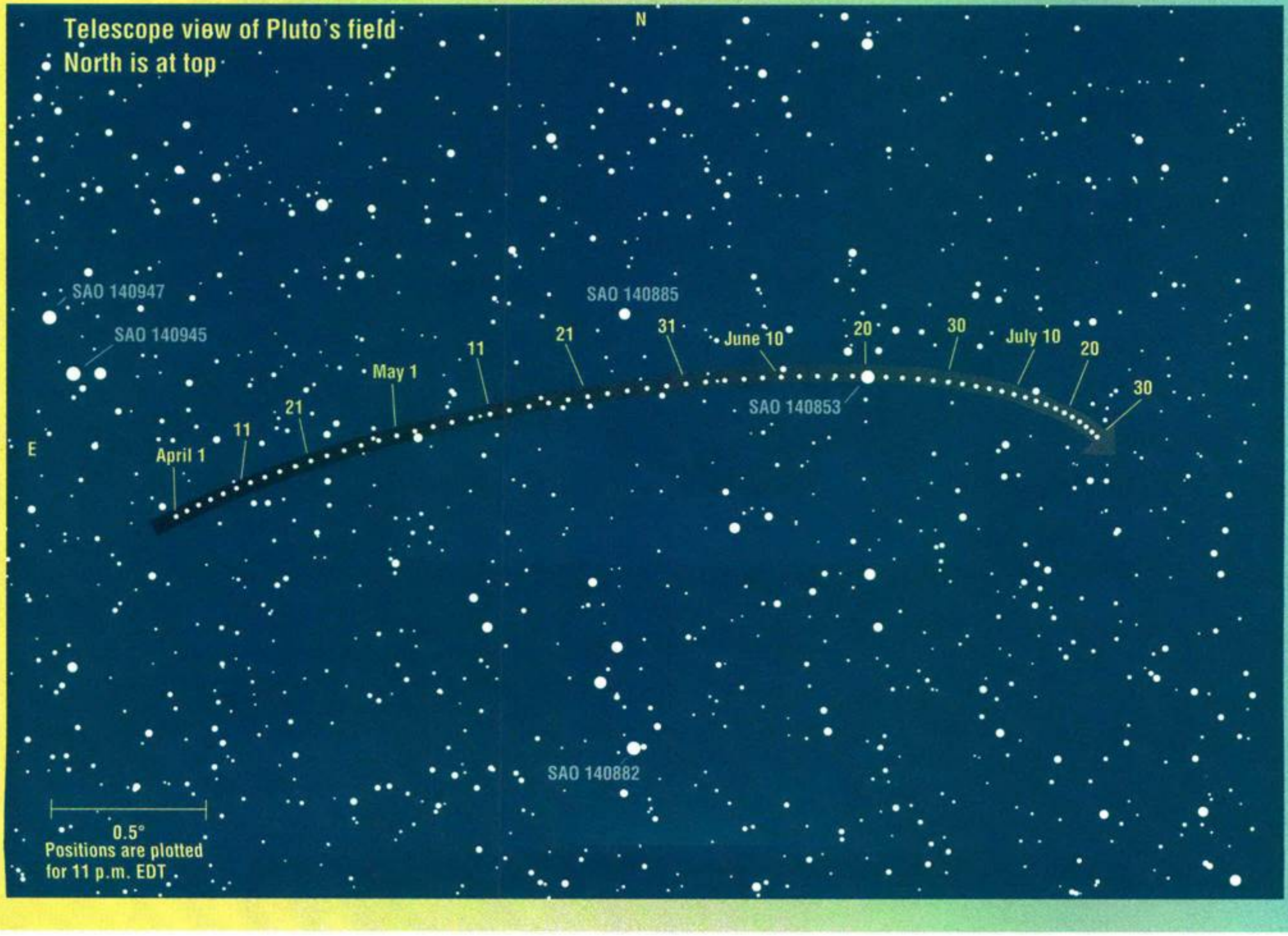
Haven't you really always wanted to see Pluto? Sure it's no brighter than the faintest star you can see in a typical 8-inch telescope, but the point is to just see it. With Pluto reaching opposition on May 20, rising near sunset, and culminating around midnight, now's your best chance this year to see the 1,429-mile-diameter world some 2.8 billion miles, or 4 light-hours, distant.

Right now Pluto lies deep in the starfields of eastern Libra, at the foot of Serpens Caput. Your search area lies 5° southeast of Delta Ophiuchi in the direction of Beta Librae. This is a fairly rich area sprinkled with magnitude 13 and 14 lookalikes, but there are a few bright 7th- and 8th-magnitude stars to use as reference points.

To get yourself oriented, look for Delta (δ) and Epsilon (ε) Ophiuchi. In a telescope at low power, scan 4° southwest of Delta and Epsilon for three stars shaped somewhat like the letter L. The stars forming the L's ascender (SAO 140947 and SAO 140945) are dominant and have nearly the same brightness. The entire asterism should be framed nicely within a 1° field of view. From the foot of the L, slew about 2½ due west and slightly south. A lone 7th-magnitude star (SAO 140853) with a string of four or so fainter stars just north of it marks the westernmost boundary of your search area. Go no farther than this. During May, Pluto's path is between 1⅓° and ½° east of that 7th-magnitude star.

Check out the finder chart below and plot your own search plan. I suggest using at least an 8-inch telescope, although the faint planet has been seen with some difficulty in 6-inch telescopes.

Obviously one of the points of light dotting the field is Pluto. But which one? As with tracking asteroids, the best way to be sure is to construct a poor-astronomer's blink comparator. Sketch the star field thoroughly and then come back two or three nights later at about the same time and make a second sketch. Be sure your field of view is oriented the same as it was the first night, with the cardinal directions on the same sides. Place the two sketches side by side and compare them for positional changes. The "star" that moves (and there should be only one) is Pluto. Point it out to your friends and family, for they will be suitably impressed. "Ah, so that's Pluto, eh? Well, well . . ." they will mumble, not really sure which faint star is Pluto but enjoying your triumph just the same. — *Jeff Kanipe*


Telescope view of Pluto's field
North is at top
N
E
SAO 140947
SAO 140945
April 1
11
21
May 1
11
21
SAO 140885
31
June 10
20
30
July 10
20
30
SAO 140853
SAO 140882
0.5°
Positions are plotted for 11 p.m. EDT

an exceedingly bright planet comes up in the east: **Jupiter**, the largest planet in our solar system.

The planet's brightness increases slightly this month as Earth prepares to pass between it and the Sun on June 1. During May it shines at magnitude –2.5 in front of the constellation Ophiuchus the Serpent Bearer. If you're still not sure of Jupiter's location, look for a waning gibbous Moon nearby on May 15. Telescopically, Jupiter has a 45"-diameter disk crossed with yellow-and-tan cloud bands and sports four large moons that change position from night to night as they orbit the giant planet.

If it were a thousand times more massive, Jupiter might now be a companion star to the Sun. Through this perspective, the planet seems giant and puny at the same time. It's puny when compared to stars like our Sun, but it's a giant among the worlds of our solar system. Its bold light in our sky compelled Greek and Roman stargazers to name it for the king of gods in their ancient pantheon.

A telescope or binoculars reveal two more gas giants, **Uranus**, in Capricornus, and **Neptune**, in Sagittarius. They come up just after midnight as May begins and rise earlier on successive evenings as each planet approaches opposition in July.

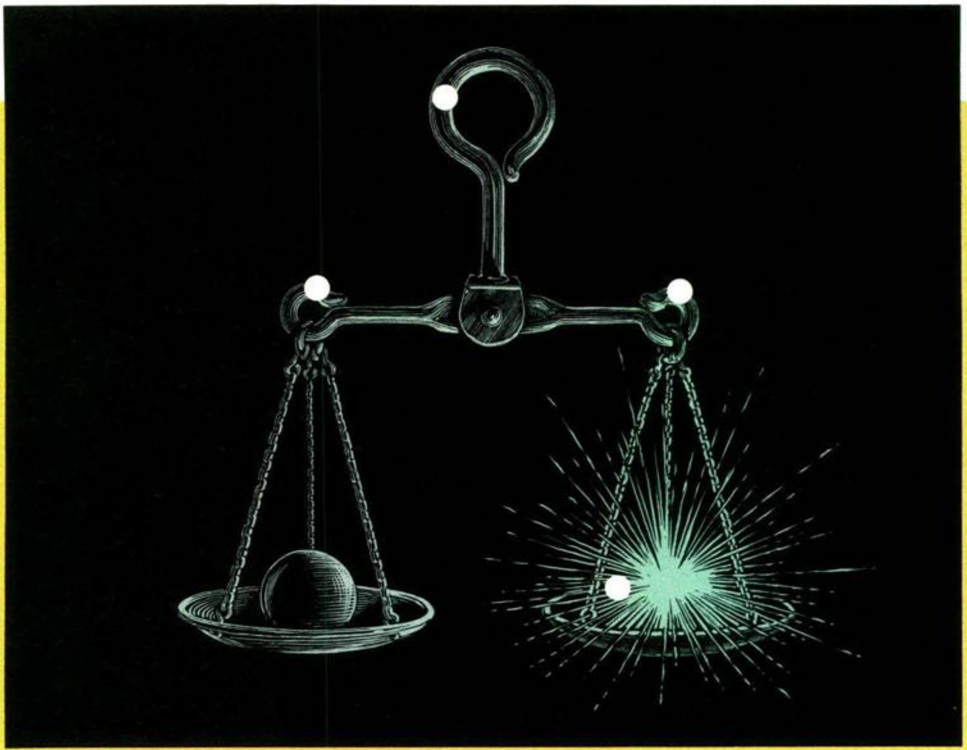
Yet another sign of Uranus' impending opposition occurs on May 5, when it begins retrograde motion. Neptune began retrograde in late April.

Usually, these planets plod eastward in front of the stars, but over the coming months they'll be moving westward. Their retrograde motion is an illusion caused by our own planet's faster orbital motion around the Sun. At around the time we pass between these outer planets and the Sun, they seem to move backward against the more distant stars.

Night passes, and Earth continues to spin eastward in front of the stars. Around 3:30 a.m. in early May, and a couple of hours earlier by the month's end, the planet **Saturn** rises in the east, looking like an inconspicuous golden "star" to the naked eye. It shines at magnitude 1.3 in Aquarius.

On May 22, for the first

The Starry Sky: **Libra**



The word zodiac means "pathway of animals." The zodiacal constellations, composed mainly of animals from mythology like Taurus, the Bull, and Scorpius, the Scorpion, mark the path of the Sun, Moon, and planets around our sky. In the whole zodiac, only one constellation does not represent a person or an animal. It is Libra, The Scales, a square-looking constellation located between Virgo and Scorpius.

The ancient Greeks did not recognize Libra as scales. They adhered to their idea of the zodiac as a pathway of animals and saw Alpha (α) and Beta (β) Librae — the two brightest stars in Libra — as the claws of the scorpion. Later, the Romans gave Libra its separate identity as the scales of justice held by Julius Caesar. Still later, the scales became associated with the nearby constellation of Virgo, the Maiden, sometimes called the Goddess of Justice. Today, Libra is known simply as The Scales, with no one in particular holding them.

This constellation's designation as the scales also stems from a time when the Sun appeared in front of Libra at the time of autumnal equinox, when days and nights are equal in length. It's not surprising, then, that many other cultures identified these stars as scales that hold the "weight" of the days in balance. Sacred books of India call this constellation Tula, which means "a balance." The Chinese knew Libra as Tien Ching, "the Celestial Balance." The Egyptians added a further belief: The scales weighed the human heart after death. The Sun now appears in front of Libra from October 31 to November 22.

Libra is not particularly bright, and its pattern is not wildly striking, but it does have two stars of some brightness. The brighter one, Beta (β) Librae, is known as Zubeneschamali, the Northern Claw, from a time when Libra's stars were considered part of Scorpius. It's possible to trace the scorpion's claws from the existing constellation Scorpius, all the way up into Libra.

Beta Librae shines at magnitude 2.6 and is one of the only stars to appear green in color. Professional astronomers say that stars cannot appear green, yet some amateur astronomers perceive Beta Librae as a green star. Does it look green to you? It does to me.

The other somewhat bright star in this constellation is Alpha Librae, also known as Zubenelgenubi, the Southern Claw. This star is a wide double with components of yellow and white that shine at magnitude 2.8. On the night of May 13, the Moon appears exceedingly close to Zubenelgenubi, which looks like a pale dot of light in the Moon's glare. — *Deborah Byrd*

Through the Ring Plane

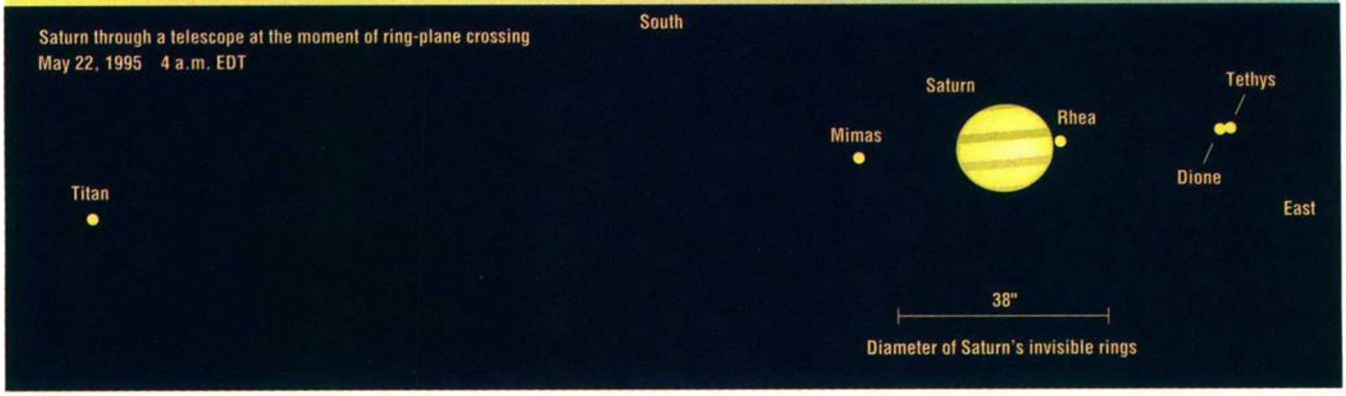
On May 22, at 4 a.m. EDT, we witness the first in a series of edge-on ring presentations of Saturn. As seen from Earth the ring system has been narrowing for the past seven years — one quarter of the planet's total orbit. As seen from Saturn on May 22, the Earth is over the planet's equator at noon on that day.

It won't be until next November that the Sun lies directly over Saturn's equator. Does this sound familiar? It should. On Earth, we would call this circumstance an equinox. Because Saturn's ring plane is essentially the same as its equator, from Earth we see a gradual shift in light from one ring face to the other.

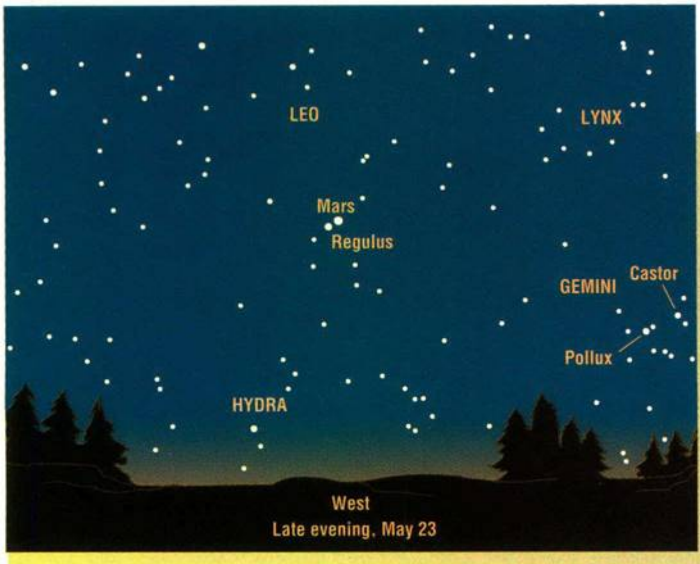
For this, the first ring-plane passage on May 22, the Sun is still north of Saturn's ring plane and the "equinox" has not yet occurred. As Earth passes through the ringplane from north to south, the northern ring face dwindles, and we cannot yet see the southern face. During May, then, the rings appear very thin, completely vanishing on May 22.

Note that Saturn is not as bright this year as it is in years when the rings are more open. A great deal of Saturn's brightness comes from sunlight reflecting from the rings (in fact, the rings contribute nearly an entire magnitude when they are most open). At opposition this year, its magnitude is 0.7. Last year's opposition magnitude was 0.5.

Shown below is a "ringless" Saturn and its moons at the moment of ring plane crossing. Look for tiny Mimas, usually lost in the glare of Saturn's rings.— *Jeff Kanipe*


Saturn through a telescope at the moment of ring-plane crossing
May 22, 1995 4 a.m. EDT

Mars Rendezvous with Regulus in Leo



Late evening, May 23

Looking overhead and just west of the meridian at sunset, we see the familiar sickle-shaped asterism of Leo. But what is that bright "star" outshining Regulus? That's Mars, which makes its closest approach to Regulus on May 23 and 24. Although the planet is near Regulus all evening (in fact, it's been stalking Leo's "heart" since winter), it comes closest just after they set for observers in mid-northern latitudes. Still, before midnight, the two bodies come within 1.3° of each other, and by the time they set, they are a tenth of a degree closer.

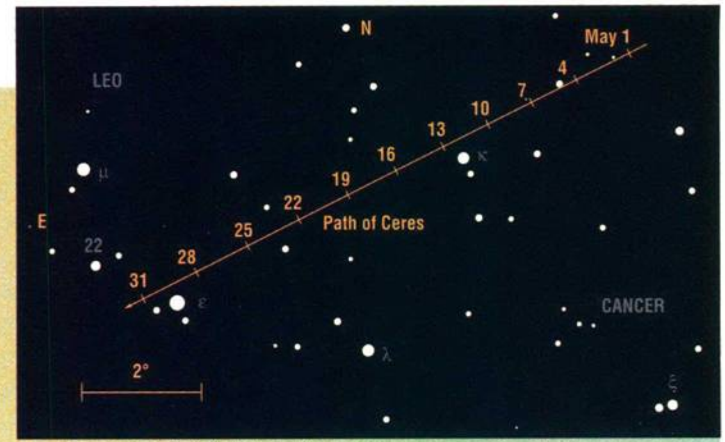
Three months past opposition, Mars still dominates the sparse spring sky at magnitude 0.9. Regulus, at magnitude 1.4, pales in comparison. Though it is one of the sky's brightest stars, Regulus may not look so brilliant next to Mars.

When looking at the duo, bear in mind their relative distances from Earth. Regulus is a blue star some 72 light years away, which means light's traveled 72 years from Regulus to reach your eye tonight. Light from Mars, on the other hand, took only 11 minutes to cross the 123,000,000-mile gulf to Earth.

One way to visualize these vast distances is to construct a scale model. If you let Mars' distance on May 23 equal one inch, Regulus would lie about 54 miles away. Taking the model a little further, Alpha Centauri, one of the closest stars to Earth at 4.3 light-years, is just over three miles away. The size of the Milky Way in our model is 76,000 miles, or about a third of the real distance to our Moon!

Oblivious to the doings of human modelers, Mars continues trekking eastward as the month progresses, straying farther from Regulus until, by late June, it lies nearly 18° southeast. — *Jeff Kanipe*

Ceres Swings Through Leo



The solar system's largest known asteroid, Ceres, makes a close pass by magnitude 4.5 Kappa (k) Leonis the night of May 12/13. Three months past opposition, Ceres is still a fairly bright minor planet at magnitude 8.5 and easy to locate if you look in the right area and are a little patient.

On the evening of the 12th, Ceres is about a quarter of a degree north-northwest of Kappa, which itself lies about 4½° northwest of Epsilon (ε) Leonis in the sickle. Center your telescope's field of view on Kappa. Although there aren't many bright stars in this region of the sky, don't confuse the pair of 7th-magnitude stars south of Kappa with Ceres. The asteroid will be in the vicinity of the star all night, but to its north. (Note that Kappa is a double star with a 10th-magnitude companion just within the glare of the primary.)

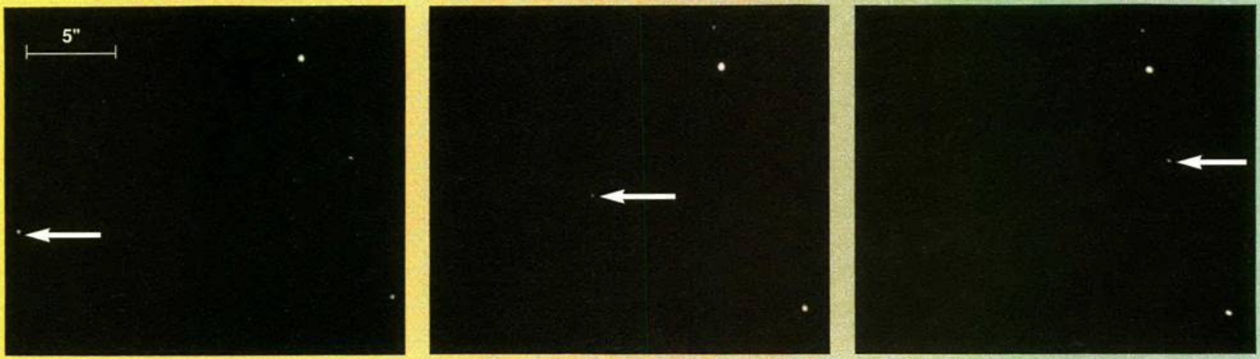
Make a detailed sketch of the starfield and compare the positions with those in the same region the following night. The "star" that has shifted position is Ceres. Or you might try monitoring the viewing field for a couple of hours. Some tiny motion may be noticeable by then. Just be sure to start observing early in the evening. That part of the sky gets pretty low around midnight.

Ceres nips by another star — Epsilon Leonis this time — on May 29/30. Look 21' north of that star. If you've been following the asteroid since its Kappa passage, you should have no trouble finding it this night. Still, be sure of your cardinal directions in the eyepiece. Two 7th-magnitude stars lie southeast of Epsilon. - *Jeff Kanipe*

COORDINATES FOR ASTEROID 1 CERES (11 P.M. EDT)

Date	**R.A. (2000)**	**Dec.**	**Mag.**
May 1	9h13.6m	27° 52'	8.4
May 4	9h16.6m	27° 30'	8.4
May 7	9h19.7m	27° 08'	8.4
May 10	9h22.9m	26° 46'	8.5
May 13	9h26.2m	26° 22'	8.5
May 16	9h29.7m	25° 58'	8.5
May 19	9h33.2m	25° 34'	8.5
May 22	9h36.9m	25° 09'	8.6
May 25	9h40.6m	24° 43'	8.6
May 28	9h44.4m	24° 17'	8.6
May 31	9h48.4m	23° 51'	8.6

The movement of Ceres over three nights



Oct.18, 1988 Oct.19, 1988 Oct. 20, 1988

time in 15 years, Earth passes through the plane of Saturn's rings, moving from north to south. At this time, the planet's rings are edgewise to Earth and cannot be seen even through large telescopes (see "Through the Ring Plane" on page 64). The following day, on May 23, Saturn appears near the moon.

One last planet, the brightest of all, ascends over the eastern horizon shortly before sunrise. This brilliant light, named for the Roman goddess of love, is Venus. At magnitude -3.9, it outshines all other celestial objects save the Sun and Moon. It is a nearly full disk as seen through a telescope, with an apparent diameter of about 11".

On the morning of May 27, you'll see the waning crescent Moon poised above **Venus** in the eastern predawn sky, looking for all the world like it's taken aim on the planet. In fact, it has.

The Moon occults, or passes in front of Venus as seen from much of Europe, in what was the dead of night for North Americans. On the morning of May 27, when we see the Moon just below Venus, enjoy thinking about how the planet emerged from behind the dark limb of the Moon only hours earlier. ☐

Deborah Byrd writes and produces the daily "Earth and Sky" radio series. Jeff Kanipe edits Star Date, the University of Texas-McDonald Observatory magazine of astronomy.

Summer Sky Spectacular

The summer sky presents outstanding nebulae, star clusters, a pinwheel galaxy — great showpieces.

by Rod Pommier

The nights are warm. The skies are clear. It's summertime again and the stars are out. The softly glowing clouds of gas and tight clumps of myriad suns are inching across the sky overhead. These emission nebulae, open and globular clusters, planetary nebulae, and galaxies provide opportunities to see detail with a small telescope or stretch the limits of your eye's acuity — and your imagination — with a larger scope.

During summer you can see fifteen of these objects in a single viewing session, a cosmic grand tour. Wait until the Moon is out of the way, leaving a dark sky, and bring your telescope, a star atlas such as *Color Star Atlas* or *Sky Atlas 2000.0*, and a dim red flashlight. (The red light will not harm the eyes' sensitivity to faint light as white light would.)

Binoculars or an 8x50 finderscope reveals each of these objects as a patch of fuzz. A 4-inch or 6-inch scope shows them as glows with distinct shapes, some peppered with faint stars or subtle details such as dark lanes or spiral arms. Larger telescopes will show progressively more detail, opening a whole new world showing these distant glows as places with distinctly unique structures.

We'll tour the sights starting in the constellation Hercules and work our way around the sky eastward, stopping well before dawn's light. The trip will carry us

The Lagoon Nebula
Mag. —
Size 90' by 40'

by Michael Stecker

NGC 6207
Mag. 11.6
Size 3.0' by 1.4'

by Preston Scott Justis

The Hercules Cluster
Mag. 5.9
Size 16.6'

by Bill and Sally Fletcher

across many light-years, so bring warm clothing, something to drink or nibble on, and perhaps some music to soothe and accompany you on your trip through the universe.

We begin with the **Hercules Cluster** (M13, NGC 6205), a perennial favorite of deep-sky observers because of its great brightness and because it rises high in the sky for northern observers. M13 is located on the west side of the distinctive Keystone asterism of Hercules. To find the cluster, aim your scope at Eta (η) Herculis, the northwest corner of the Keystone. Move your scope 2½° south and the cluster will be visible in your finderscope as a fuzzy "star." It forms a small isosceles triangle with two 7th-magnitude stars flanking it on the south and east. With a magnitude of 5.9, the Hercules Cluster is visible to the naked eye on a very dark night.

In binoculars, the cluster appears as a fuzzy disk without individual stars. It shines with a soft gray-green glow. In a 4-inch or larger scope, the cluster begins to show its glory, individual faint stars appearing along the edges of its glowing disk. In an 8- or 10-inch scope, the cluster resembles a sparkling "snowball" of countless tiny stars and appears surprisingly three-dimensional. Don't be afraid to use magnification in the range of 100x to 150x on this object. This will darken the background sky, allowing the faint cluster members to stand out.

Curiously, the cluster has a Y-shaped dark lane. The Y divides the cluster into two small areas and one large area, because the fork of the Y is considerably off-center. Also, while you're in the area, check out the tiny spiral galaxy **NGC 6207**, just northeast of the cluster. The bright dot in the nucleus of the galaxy is a foreground star superimposed on the galaxy's center.

Working our way eastward and southward brings us to Sagittarius, where resides the **Lagoon Nebula** (M8, NGC 6523). This emission nebula glows by fluorescence and lies along our line of sight toward the center of the Milky Way Galaxy. On moonless nights, the Lagoon is visible to the naked eye as a small patch just above the spout of the Teapot asterism in Sagittarius. Through a 6-inch small telescope, M8 appears as an oval cloud bisected by a curving dark lane, or lagoon. This is B89, one of the prominent dark nebulae catalogued by 19th-century astronomer E. E. Barnard. A 10-inch scope shows a wealth of fine details in both the nebula and its lagoon. Be sure to check out the open cluster NGC 6530 embedded on the east side of the dust lane. The symmetry of this cluster, which is slowly forming out of the nebula's gas, is striking. NGC 6530 would be a showpiece itself if it weren't overshadowed by the Lagoon Nebula.

Our next stop is the **Trifid Nebula** (M20, NGC 6514), just 2° north-northwest of the Lagoon. The Trifid sports two areas of nebulosity, a bright southern portion and a dimmer northern part. The brighter area is emission nebulosity and the fainter part reflection nebulosity, meaning it glows by starlight reflected off dust grains. Each half has a bright star near its center. The emission nebula explains the name Trifid from "tri"; carefully note three dark lanes that intersect at its center.

Through a 6-inch or larger scope, the Trifid appears

The Trifid Nebula
Mag. —
Size 29' by 27'

by John P. Gleason

Open Cluster M21
Mag. 5.9
Size 13'

by George R. Viscome

softer and prettier than the Lagoon. Try using 100x to 150x for the most detailed views. It may take more power to split cleanly the double star in the center of the Trifid. Less than 1° northeast of M20 lies the beautiful open cluster **M21** (NGC 6531). This cluster contains 70 members lying at a distance of about 4,000 light-years. It, too, is often ignored because of its more complex and alluring neighbor.

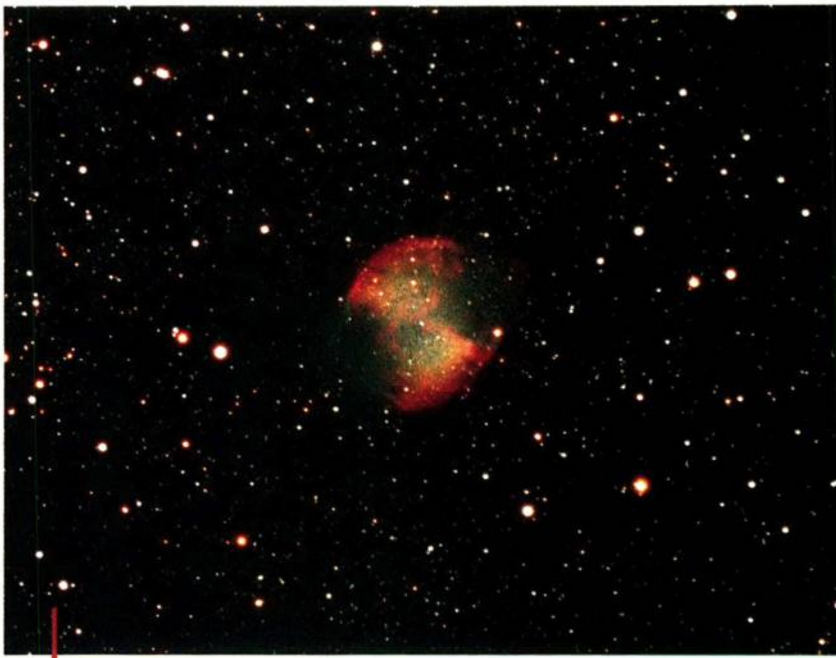
Next, we'll take in the **Omega Nebula** (M17, NGC 6618), which lies north of M21 in the northern part of the constellation. On moonless nights binoculars show the Omega as a bright fuzzy spot set against the Milky Way. The 18th-century observer William Herschel named this object Omega because of its small omega-shaped, or horseshoe-shaped, portion that outlines a dust cloud. In 3-inch or 4-inch scopes only a cigar-shaped streak of nebulosity is visible, making the Omega look like an edge-on spiral galaxy. Six-inch scopes reveal an additional rectangular patch of nebulosity aligned at nearly a right angle from one end of the cigar, converting M17 into a checkmark shape. Eight-inch or larger instruments reveal the hook of the omega attached to the beginning of the checkmark.

As the mid-evening hours roll by, look up to the zenith to find the constellation Lyra. Here you'll find a planetary nebula, the expanding remnant gases of a dying star. The **Ring Nebula** (M57, NGC 6720) is easy to locate, situated about midway between Beta (β) and Gamma (γ) Lyrae. M57 spans only 70", but it is quite bright. Through a small scope, M57 appears as a small spot of light. Six- to 8-inch scopes reveal a smoke ring, resembling a Cheerio. Ten- or 12-inch scopes show faint nebulosity in the central hole. Use high powers on the Ring, as it bears magnification well.

High powers may reveal the most elusive part of M57, its dim central star. At magnitude 14.5, the star may require a 16- or 20-inch scope to be seen. Some observers claim to have seen it with much smaller scopes. I've spotted it with a 24-inch scope on some nights but missed it with a 32-inch scope on other occasions.

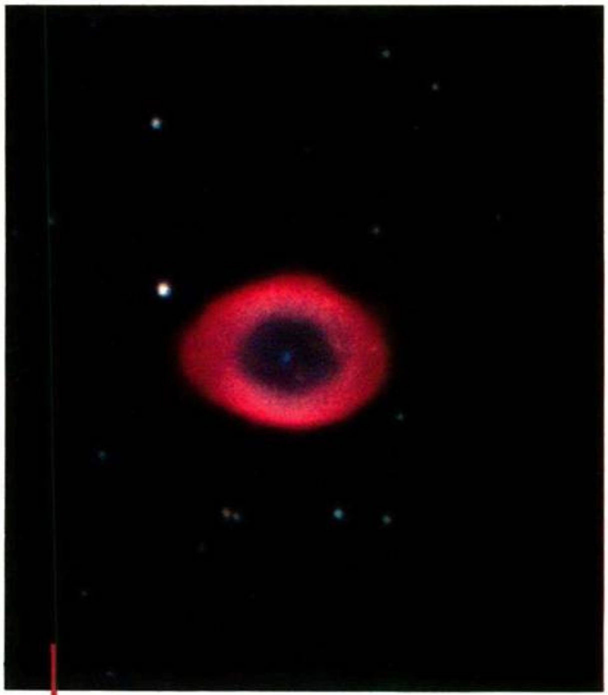
Another planetary lies to the south in the small constellation Vulpecula. The **Dumbbell Nebula** (M27, NGC 6853) is one of the brightest planetaries in the sky. To find it, start at the star Gamma Sagittae. Move about 3° north to find a group of stars that includes 13, 14, and 16 Vulpeculae. This group forms a very distinctive M shape (or a W in an inverting finderscope) with 14 Vulpeculae being the middle star. The Dumbbell lies just south of 14 Vulpeculae.

In telescopes, the Dumbbell appears large, measuring 350" across. In 4- to 6-inch scopes it resembles a cookie with bites taken out on opposite sides. Eight-inch or larger scopes reveal a circular to oval disk, the bites filled-in with faint nebulosity. Larger scopes reveal "ears" extending outward from these dimly glowing regions. In most scopes, the surface of M27 has a mottled appearance because of clouds and knots of gas of differing densities within it. Look for bright arcs near the northern and southern edges. Through moderate-aperture scopes, several faint stars can be seen against the glowing light. Be sure to look for the Dumbbell's central



The Dumbbell Nebula
Mag. 7.6$_P$
Size 350"

by Jerry Lodriguss



The Ring Nebula
Mag. 9.7$_P$
Size 70"

by Tony and Daphne Hallas

The Andromeda Galaxy
Mag. 3.5
Size 178' by 63'
(with asteroid 895 Helio passing in front of satellite galaxy NGC 205, on September 10, 1994)

by Tony and Daphne Hallas

The Omega Nebula
Mag. —
Size 46' by 37'

by Scott Hicks

The Wild Duck Cluster
Mag. 5.8
Size 14'

by Jack Newton

star. At magnitude 13.9, it's within reach of an 8-inch scope, but some observers can glimpse it with a 6-inch on exceptional nights.

By now it's probably late evening and the sky has wheeled around further. We can look under the belly of the Milky Way in Scutum to find the **Wild Duck Cluster** (M11, NGC 6705). The Wild Duck is one of the densest open clusters visible and is easy to find. Begin at Lambda (λ) Aquilae. Follow a gentle curve of stars southwest through 12 Aquilae to Eta Scuti. Proceed directly west to a small quadrangle of 6th and 7th magnitude stars. The Wild Duck lies less than 1° southeast of this quadrangle and should be immediately visible as a fuzzy spot in your finderscope.

The brightest members of the Wild Duck form a distinctive arrowhead pattern. This led the 19th-century observer William Henry Smyth to compare the cluster to "a flight of wild ducks." If you have difficulty spotting the arrowhead pattern, concentrate on the breaks in the cluster; they outline it sharply. The group lies 5,500 light-years away and contains approximately 500 stars.

Now, as late evening slips well into the wee hours, head out of the Galaxy to the **Andromeda Galaxy** (M31, NGC 224), the brightest and closest spiral in the sky. Visible to the naked eye, the galaxy is easy to locate. Begin at the northeast corner of the Great Square of Pegasus, the star Alpheratz, Alpha (α) Andromedae. Move northeast through Delta (δ) to Beta Andromedae. From Beta, proceed northwest to Mu (μ) and then Nu (ν) Andromedae. Nu Andromedae forms the northeast corner of an isosceles triangle of 5th-magnitude "stars" visible to the naked eye. However, the apex of this triangle is not a star at all but the Andromeda Galaxy.

About 1½° southeast of the galaxy's center you may see a patch of light brighter than the surrounding area. This is **NGC 206**, an immense star cloud in one of the spiral arms bright enough to have earned its own NGC number in the late 1800s. Be sure to look at M31's satellite galaxies, **M32** (NGC 221) and **NGC 205**. M32 is closest to M31 and is a dwarf elliptical galaxy. It is fairly bright and resembles an unresolved globular cluster without a central core, but with a very small, almost stellar, nucleus. NGC 205 is considerably farther from M31, toward the northwest. It is a dwarf elliptical too but is considerably dimmer, as it is spread over a larger surface area. It has a brighter core but no sharp nucleus. Spend plenty of time looking at the Andromeda Galaxy and its surrounding pals. The longer you look, the more you'll see in this majestic system.

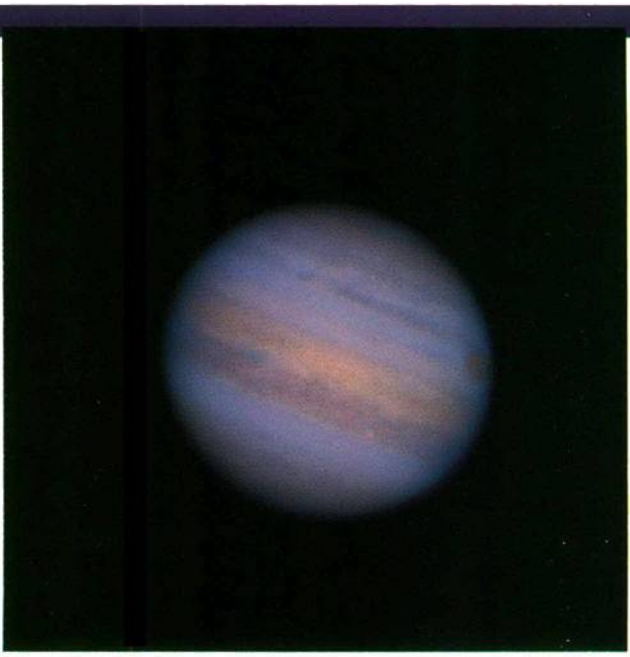
These bright and easy-to-find objects provide a mere taste of the deep-sky treasures that litter the arch of the summer Milky Way. See them all on a single evening if you can and you'll be able to compare them with fresh images in mind. But come back to them again, for the more you look at them the greater number of minute details your eye will detect. Beware, however, as you may find yourself hooked on deep-sky observing. □

Rod Pommier is assistant professor of surgery at the Oregon Health Sciences University in Portland. He is an avid deep-sky observer.

JUPITER at its best

The next two months bring this year's best viewing of Jupiter, a planet with more atmospheric detail and satellite activity than any other.

by Wynn Wacker



Charles Capen

The planet's turbulent atmosphere sometimes changes appearance from one night to the next, but its most dramatic features are huge storms that rage for decades, even centuries. Probed in detail last summer when fragments of Comet Shoemaker-Levy 9 crashed into it, this atmosphere will be studied again in December when the Galileo spacecraft arrives. Welcome to Jupiter, which grows more conspicuous this month as it moves toward opposition on June 1.

Jupiter has something to offer backyard observers with any size telescope. Even the smallest of apertures (2 to 3 inches) reveal the prominent atmospheric bands and movements of the four largest satellites in their perpetual dance around the planet, (called the Galilean satellites after their discoverer, Galileo). Named Io, Europa, Ganymede, and Callisto in order of increasing distance from Jupiter, the satellites display a number of interesting phenomena. (See "Tracking the Galilean Satellites," page 74.) Four-inch and larger telescopes reveal changes in the planet's cloudtops, while still larger apertures reveal delicate cloud features when conditions allow.

The limiting factor in detecting fine detail in Jupiter's atmosphere lies much closer to home. Turbulence in Earth's atmosphere causes images in the eyepiece to blur. Poor "seeing" is particularly a problem when Jupiter lies low in the sky, as it will for northern observers throughout most of this summer's apparition. It now lies in the southern constellation Scorpius, which places it relatively low but does provide an opportunity to get acquainted with the planet on the balmy nights of late spring and summer.

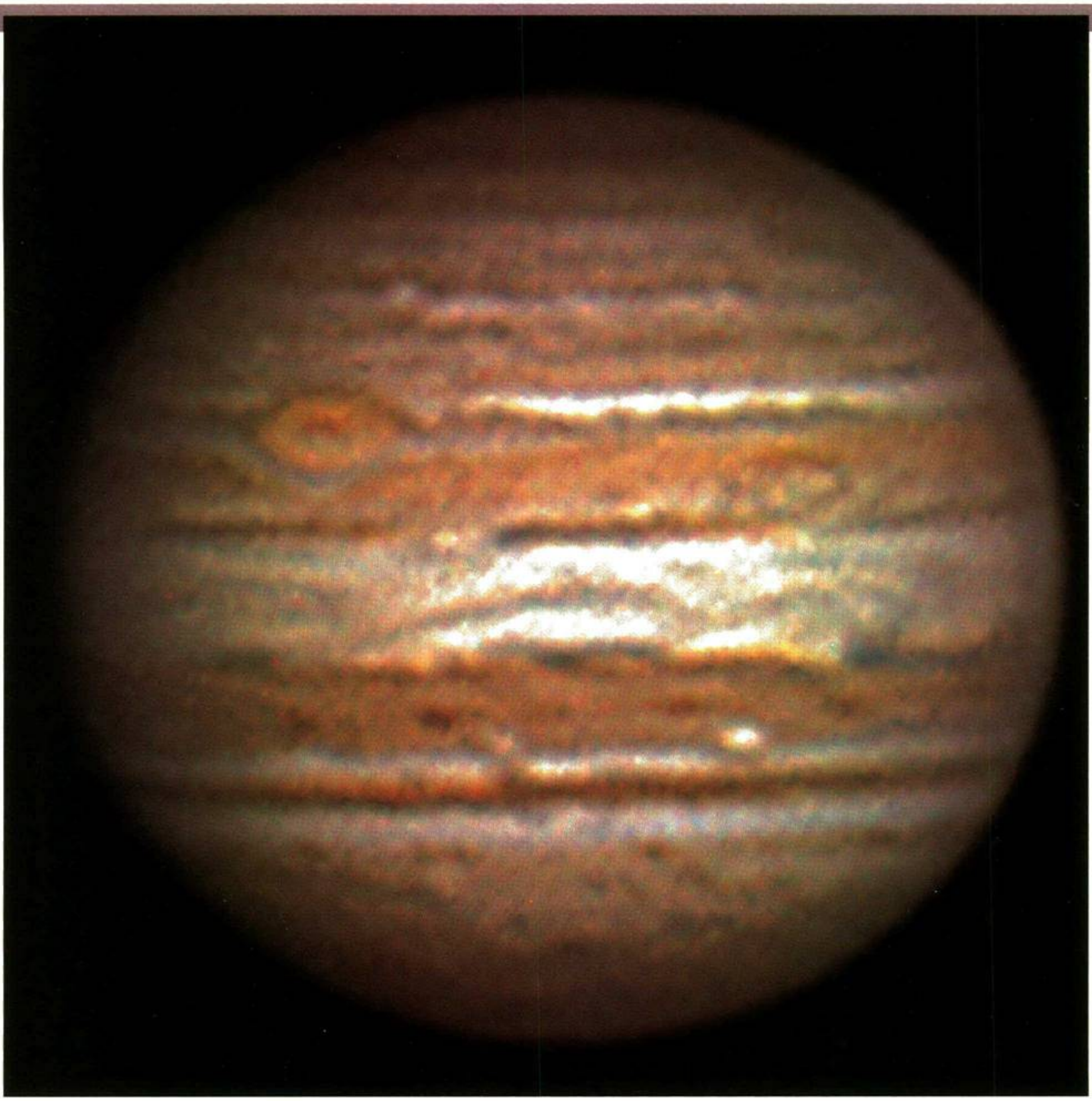
To see the most, avoid pointing your telescope over surfaces that absorb and retain heat during the day, such as buildings and asphalt parking lots. Grass moderates surface temperature, so lawns and fields are good surroundings. The transparency (haziness) of the atmosphere also plays a role. Heavy haze diffuses light and lowers contrast. But haze high in the atmosphere often has a steadying effect and improves seeing.

The ultimate factor in determining what can be seen is the observer. Many people give up in disappointment after gazing at the planet for only a few minutes. Like any skill, planetary observing requires patience and practice. It involves integrating the bits of detail glimpsed in the steadiest moments of seeing into a mental image of what's there.

The first step in observing the disk is to get oriented. If you turn off the clock drive on your scope, the eastern limb of the planet leaves the field of view first. Moving the telescope south in declination makes the north limb of the planet leave the field first. Because most telescopes invert the image, astronomical convention places the planet's south pole at top, the north pole at bottom, the eastern limb to the left, and the western limb to the right.

As with the other gas giant planets, Jupiter's rapid rotation causes it to bulge in the middle, giving it an equatorial diameter more than 6 percent larger than the polar diameter. A modest telescope reveals light zones and dark belts running parallel to the equator. Zones are cooler regions where bright ammonia ice clouds condense, while belts are warmer areas where descending air evaporates the ice clouds and opens a view to deeper cloud layers. Fortunately, rapid rotation keeps the latitudes of the belts and zones fairly stable.

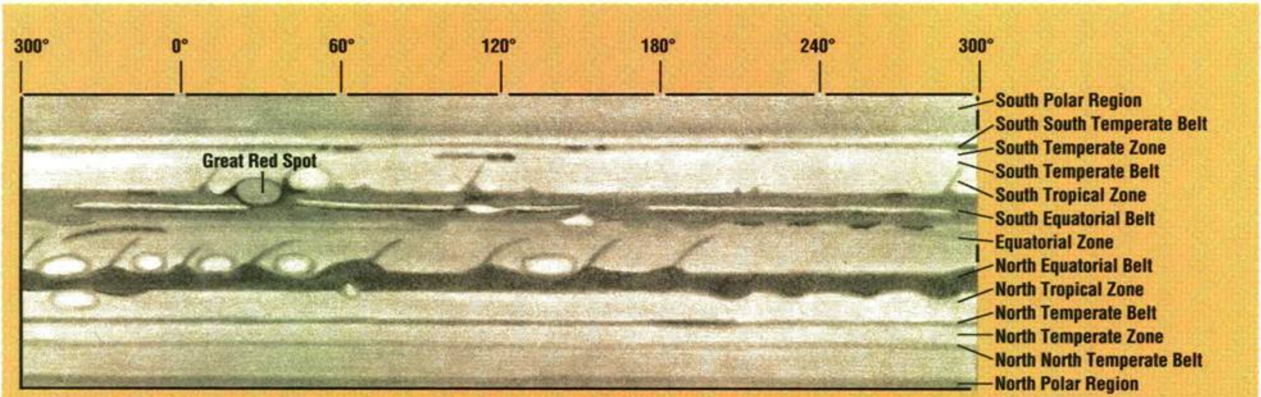
Straddling the equator, the Equatorial Zone is usually bright but occasionally becomes dusky. Sometimes the Equatorial Band is seen as a thin belt running through the center of it. On either side of the equator, at approximately 15° latitude, are the North and South Equatorial Belts. These are the most prominent belts and are nearly always visible, even in small telescopes. The two usually appear at least somewhat different: The South Equatorial Belt (SEB) is usually the less dark of the two and often



Donald C. Parker

JUPITER'S TURBULENT ATMOSPHERE offers intricate details for observers with any size telescope. Capturing those details on film or with a CCD camera requires short exposures in moments of good seeing (above).

DARK BELTS AND LIGHT ZONES stretch completely around Jupiter parallel to its equator (below, shown with longitude 120° at center). Because Jupiter rotates in less than 10 hours, you can view the entire planet in a single night.


300°
0°
60°
120°
180°
240°
300°
Great Red Spot
South Polar Region
South South Temperate Belt
South Temperate Zone
South Temperate Belt
South Tropical Zone
South Equatorial Belt
Equatorial Zone
North Equatorial Belt
North Tropical Zone
North Temperate Belt
North Temperate Zone
North North Temperate Belt
North Polar Region

Paul A. Smith and Matthew J. Boulton

Tracking the Galilean Satellites

Although the features in Jupiter's cloudtops remain fairly constant from one night to the next, the same can't be said for the planet's satellites. Any telescope will let you follow the changing positions of the four Galilean satellites, named for the man who discovered them in 1610, as they orbit Jupiter. And even steadily held binoculars easily reveal the outer two.

Io, Europa, Ganymede, and Callisto (in order of distance from Jupiter) are worlds in their own right. Ganymede ranks as the largest satellite in the solar system (even larger than the planet Mercury), and only Europa comes in smaller than the Moon. The inner satellites move fast enough in their orbits that you can note their changing positions over the course of an hour or two. For the outer satellites in their more stately orbits, it might take a full 24 hours to detect their motion.

The most exciting time to view the satellites is when they are close to passing in front of or behind the giant planet. When Io, Europa, or Ganymede pass in front of Jupiter, you can watch as both their disks and their shadows transit the planet. When the satellites head behind Jupiter, they are both occulted by the disk of the planet and eclipsed by the planet's shadow. Callisto remains visible throughout this year; its orbit takes it north of Jupiter when it passes in front and south of Jupiter when it passes behind.

Before opposition on June 1, shadows cross Jupiter before the satellite disks do and eclipses occur before occultations. After opposition the Sun shines from the opposite direction as seen from Earth, so the shadows cross after the disks and occultations come before eclipses. The table below lists the best such events for North American observers for the month before and after opposition. Times are given in eastern daylight: Subtract 1 hour for central time, 2 hours for mountain time, and 3 hours for pacific time.

Ronald Royer

Phenomena of the Galilean Satellites

Date	Event	Time (EDT)
May 2	Io shadow enters	2:41 a.m.
	Transit begins	3:22 a.m.
	Shadow leaves	4:52 a.m.
	Transit ends	5:33 a.m.
May 2/3	Io eclipse begins	11:53 p.m.
	Occultation ends	2:43 a.m.
May 10	Io eclipse begins	1:46 a.m.
	Occultation ends	4:28 a.m.
May 10/11	Io shadow enters	11:03 p.m.
	Transit begins	11:34 p.m.
	Shadow leaves	1:14 a.m.
	Transit ends	1:44 a.m.
May 11/12	Europa shadow enters	11:17 p.m.
	Transit begins	12:14 a.m.
	Shadow leaves	1:47 a.m.
	Transit ends	2:42 a.m.
May 18	Io shadow enters	12:57 a.m.
	Transit begins	1:18 a.m.
	Shadow leaves	3:09 a.m.
	Transit ends	3:29 a.m.
May 19	Europa shadow enters	1:50 a.m.
	Transit begins	2:29 a.m.
	Shadow leaves	4:21 a.m.
	Transit ends	4:57 a.m.
May 23	Ganymede shadow enters	12:10 a.m.
	Transit begins	1:12 a.m.
	Shadow leaves	2:24 a.m.
	Transit ends	3:11 a.m.
May 25	Io shadow enters	2:51 a.m.
	Transit begins	3:02 a.m.
	Shadow leaves	5:03 a.m.
	Transit ends	5:13 a.m.
May 26	Io eclipse begins	12:02 a.m.
	Occultation ends	2:21 a.m.
May 27/28	Europa eclipse begins	11:21 p.m.
	Occultation ends	2:05 a.m.
June 2	Io occultation begins	1:55 a.m.
	Eclipse ends	4:07 a.m.
June 2/3	Io transit begins	11:12 p.m.
	Shadow enters	11:14 p.m.
	Transit ends	1:23 a.m.
	Shadow leaves	1:26 a.m.
June 4	Europa occultation begins	1:50 a.m.
	Eclipse ends	4:30 a.m.
June 10	Io transit begins	12:56 a.m.
	Shadow enters	1:09 a.m.
	Transit ends	3:07 a.m.
	Shadow leaves	3:20 a.m.
June 17	Ganymede occultation begins	12:38 a.m.
	Eclipse ends	4:22 a.m.
June 17	Io transit begins	2:41 a.m.
	Shadow enters	3:03 a.m.
	Transit ends	4:52 a.m.
	Shadow leaves	5:15 a.m.
June 17/18	Io occultation begins	11:49 p.m.
	Eclipse ends	2:23 a.m.
June 20	Europa transit begins	12:32 a.m.
	Shadow enters	1:24 a.m.
	Transit ends	3:01 a.m.
	Shadow leaves	3:56 a.m.
June 25	Io occultation begins	1:34 a.m.
	Eclipse ends	4:18 a.m.

appears as two components with a lighter region between them.

Poleward from the equatorial belts lie the North and South Tropical Zones. Beyond the tropical zones rest the North and South Temperate Belts. These are thinner and less prominent than the equatorial belts, and occasionally are not visible at some longitudes. The South Temperate Belt is often darker near the Red Spot. Belts closer to the poles are often faint or fragmentary, and tend to fade into the shading of the polar regions. If the Comet Shoemaker-Levy 9 impact debris persists long enough, observers this year may see a dark reddish belt near latitude – 44°.

Superimposed on this network of belts and zones are cloud features of varying lifetimes. At least eighteen major types of light and dark features are recognized by the Association of Lunar and Planetary Observers. The planet's rotation carries them across the visible disk from the western to the eastern limb. Because Jupiter rotates so quickly (in less than 10 hours), markings shift visibly in a few minutes.

The most famous and long-lived feature (perhaps over 300 years old) is the Great Red Spot. It sits in a light oval region in the South Tropical Zone called the Red Spot Hollow, which dips into the South Equatorial Belt to the north and touches the South Temperate Belt to the south. The visibility of the Red Spot varies inversely with the SEB's darkness: When the belt is extremely dark and active, the Red Spot may fade away altogether, leaving only the light Hollow to mark its place. Conversely, when the SEB occasionally fades, the Red Spot is usually dark and prominent. For a time last summer, the Red Spot was about the same intensity as the broad, uniform SEB and was difficult to pick out under moderate seeing.

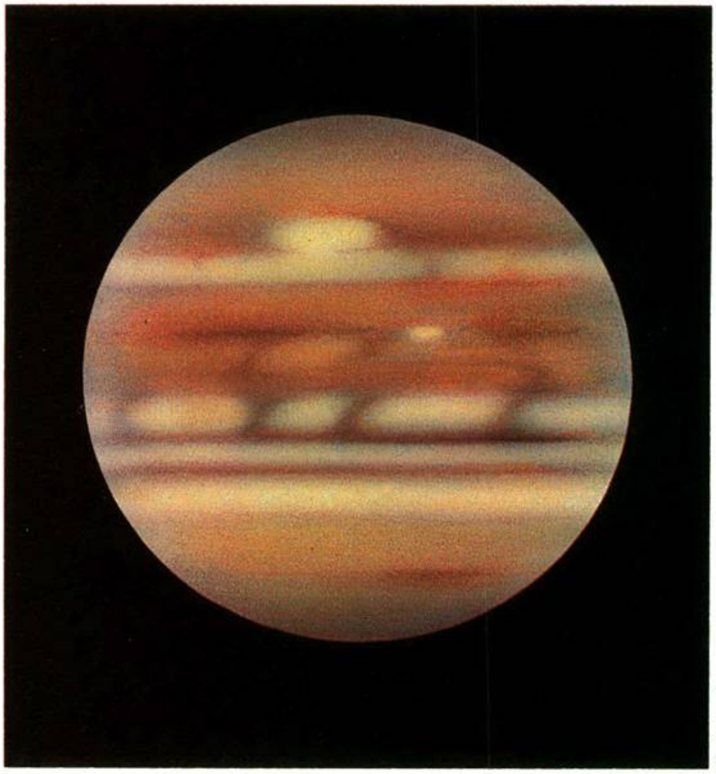
Another set of persistent features is the South Temperate Ovals, white spots located in the South Temperate Zone and along the south edge of the South Temperate Belt. The three ovals, labeled FA, BC, and DE, have existed since the 1940s, though they've shrunk to look more like round spots than ovals.

The region of the North Equatorial Belt (NEB), usually the most active area of the planet, displays the richest color contrasts. Festoons slanting from its south edge into the Equatorial Zone are often strikingly blue in color. These prominent features are often the first noticed by beginning observers, and usually two or three are visible on the disk at any given time. Brown "barges," oval-shaped features near the north edge of the NEB, first appear round, like satellite shadows, and then are drawn out by prevailing winds to dashlike markings of rich red-brown. Occasionally plumelike reddish-brown "horsetails" issue from the eastern end of barges to slant across the NEB in a southeastern direction. The belt itself is usually orange-brown. White rifts cutting into the south edge of the belt and white spots along the north edge are both common occurrences.

On other belts, activity is more sporadic. The South Equatorial Belt sometimes fades, occasionally to invisibility, only to revive following an outbreak of bright and dark spots that issue from one or more "sources." This phenomenon is termed an SEB Disturbance, and the most recent one occurred in 1993. Outbreaks of spots have also been seen on the North Temperate Belt and North North Temperate Belt. Zones also display occasional outbreaks of unusual activity, generally accompanied by a decrease in brightness.

Use color filters to bring out different features. A Wratten #25 (red) filter will show the blue festoons nicely and a Wratten #38A (light blue) filter reveals the reddish clouds. Other filters, such as Wratten #82A (very light blue) and #12 (yellow) enhance the contrast between light and dark areas in general. Viewing the planet while the sky is still light often improves perception of color contrasts without filters.

The cloud patterns drift with prevailing atmospheric currents. Their positions are located in reference to arbitrary systems of longitude having constant rotation periods. Rotation is most rapid in the region of the equator, and longitude System I, with a rotation period of 9 hr 50 min 30 sec, is used for features lying between the middle of the NEB and the middle of the SEB. Markings lying outside of that region are located with respect to longitude System II, which has a rotation period of 9 hr 55 min 41 sec. Longitude System III, with a duration of 9 hr 55 min 30 sec, measures the period of Jupiter's radio emission and is believed to represent the rotation period of the core of the planet.



Edwin Faughn

THE EYEPIECE IMPRESSION of Jupiter on an excellent night can be stunning, revealing wondrous detail in the colorful cloudtops.

The position of a feature is determined by noting the time when it appears to lie on the central meridian, an imaginary line connecting the poles of the planet through the center of the disk. The appropriate longitude can then be computed from tables in almanacs or with a computer program (for a BASIC program that accomplishes this, see "Computing Mars and Jupiter," July 1993.) The longitude drift of markings over time provides the data to map currents in Jupiter's atmosphere. For observing forms and more information, including how to submit reports of your observations, contact José Olivarez, ALPO Jupiter Recorder, 1469 Valleyview Court, Wichita, KS 67212.

Between the dance of the satellites and the ever-changing colorful clouds, Jupiter never looks the same twice. Take this warm weather opportunity to become acquainted with the monarch of planets. ☐

Wynn Wacker is a longtime Jupiter observer living in Madison, Wisconsin.

LIFE IN THE FAST LANE

Looking for the best ultrafast slide film for astrophotography? ASTRONOMY pits two new contenders against the reigning champion. The result is an upset victory.

Photos and text by Alan Dyer

We astrophotographers are like shipwrecked sailors parched with thirst on a desert island. Ironically, water is all around us. In our case, it's an ocean of new color films from Kodak, Fuji, and other manufacturers that laps at our shores. Yet few of these satisfy our thirst for a fast color film for capturing the night sky. All too often when a manufacturer "improves" a favorite film, the new version turns out to be unsuitable for most astrophotography.

For photographing faint deep-sky targets in color, we need a film with fast speed, fine grain to show details, and good sensitivity to the red end of the spectrum, where many nebulae emit much of their light. The ideal deep-sky film should have little reciprocity failure, meaning it should retain most of its speed even during exposures lasting 30 minutes or more. And during those long exposures, it should remain neutral in its response and not shift its color balance to some off-color tint. We don't want green or purple skies.

Is there such a film? In slide films, the choice during the last few years has been very slim. In October 1992, ASTRONOMY conducted a comparison test of fast slide films then on the market in North America and found that 3M ScotchChrome 400 came closest to the ideal. (See "Selecting the Right Slide Film.") It exhibited remarkable recording power, picking up faint nebulosity without any need for finicky special treatments such as gas hypersensitization. ScotchChrome's main drawback was its coarse grain compared to other ISO 400-class films and its tendency to turn magenta during long exposures. It is also difficult to find a supplier for this film. (Call 3M at 800-695-FILM for the dealer nearest you.)

Now ScotchChrome has a serious competitor. In 1994 both Fuji and Kodak introduced new versions of their ultrafast slide films. I tested both these emulsions against ScotchChrome and found a clear winner.

Two New Contenders

The new ultrafast emulsion from Fuji is Provia 1600, coded as RSP 135. It replaces Fujichrome P1600D and forms the fast end of Fuji's new Provia line of slide films (also available in ISO 100 and 400 speeds). Fuji aims the Provia films at professional photographers but also sells them to consumers under the Sensia brand of Fuji films. However, the 1600-speed slide film is only available in the professional Provia line.

Kodak also revamped its line of slide films in 1994, introducing professional Lumiere emulsions and corresponding consumer films called Elite. The new Ektachrome P1600 (code number EPH 5040) doesn't carry either designation, but as my tests showed, it is clearly a new film. It behaves quite differently than the Ektachrome P800/1600 (code EES 5020) it replaces.

Both these new 1600-speed films are actually ISO 400 films that require push-processing to bring out their best characteristics. Pushing a film means keeping the film in the first developer a few extra minutes. This effectively increases the film's speed, with the tradeoff being an increase in film grain and a grayer film background. Most photo labs can push films, but photographers must ask for this service when taking the film in for developing and pay a surcharge for the special processing.

To achieve an ISO 800 speed, the new Kodak and Fuji films must be pushed one stop. An ISO speed of 1600 requires a two-stop push while achieving a speed of ISO 3200 requires a three-stop push. The film canisters have a place to indicate how many stops to push-process the film.

ScotchChrome 400 is also a "pushable" film. For several years I have regularly shot this film at ISO 800 with good results. Pushing ScotchChrome one stop produces only a slight increase in grain over shooting it straight at ISO 400, yet all exposure times can be cut in half, a great benefit when shooting 30-minute or longer exposures.

(continued on page 80)

THE CYGNUS STARFIELDS and nebulosities stand out in this 8-minute exposure at f/2 on Ektachrome P1600. This new slide film is proving to be one of the best for deep-sky astrophotography. Even when pushed to ISO 1600 (as it is here), it remains fine grained.

1600
DAYLIGHT
Professional
PROVIA
FOR PUSH PROCESSING
FUJICHROME
36
1600
RSP 135
DAYLIGHT
PROVIA
FOR PUSH PROCESSING
FUJICHROME
36 EXP
400
ScotchChrome
35 mm
DX
35mm Film for Color Slides
Kodak
Ektachrome
P1600
PROFESSIONAL FILM
36 EXPOSURES
EPH 135-36
Ektachrome
P1600 PROFESSIONAL

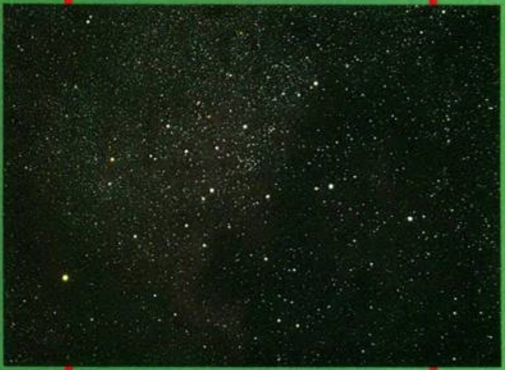
ASTRONOMY: Jim Forbes

PRIME FOCUS

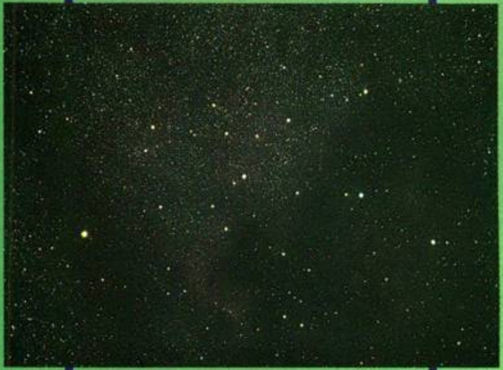
FRAMES AT ISO 800

FRAMES AT ISO 1600

Fujichrome Provia RSP



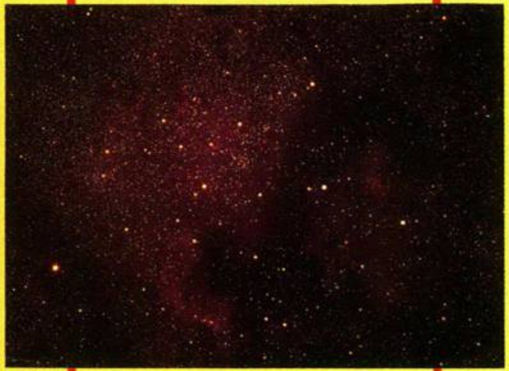
35 min. at f/4.5



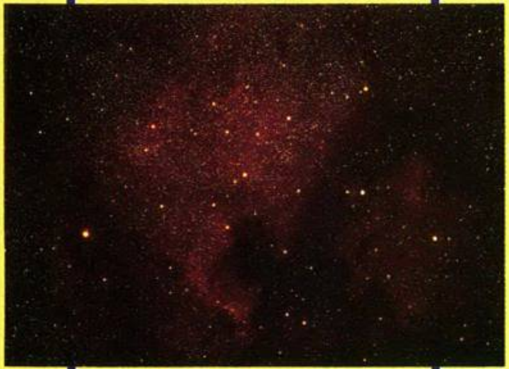
18 min. at f/4.5

FINE GRAINED, Fuji Provia shot at the prime focus of a 4-inch refractor also exhibited good reciprocity characteristics. When processed at ISO 1600, its contrast dropped (the sky became washed out). This film had difficulty recording red nebulosity and showed a strong cyan shift in long exposures, making this the least suitable of the trio for deep-sky photography.

Ektachrome P1600 EPH



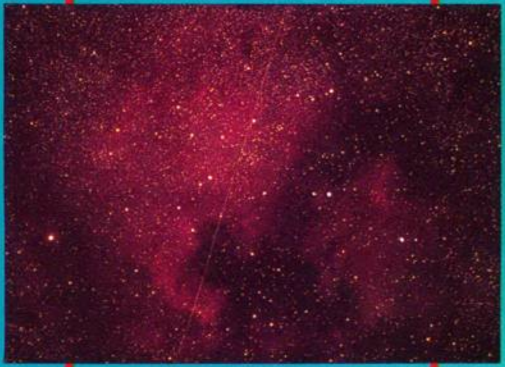
35 min. at f/4.5



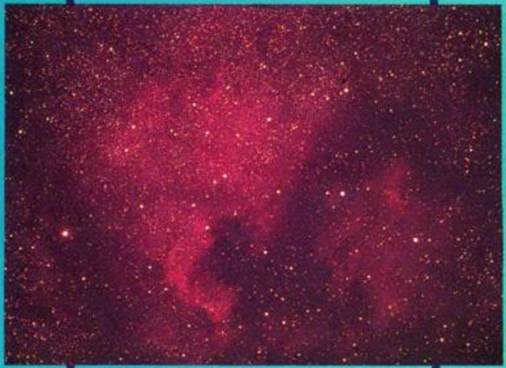
18 min. at f/4.5

GOOD SKY CONTRAST and a dark neutral sky color marked exposures using Ekachrome P1600. Tests using the same exposure times as for the other two films picked up red nebulosity very well. Processing at ISO 1600 increased film grain and decreased contrast but required only half the exposure time of a roll developed at ISO 800.

ScotchChrome 400



35 min. at f/4.5



18 min. at f/4.5

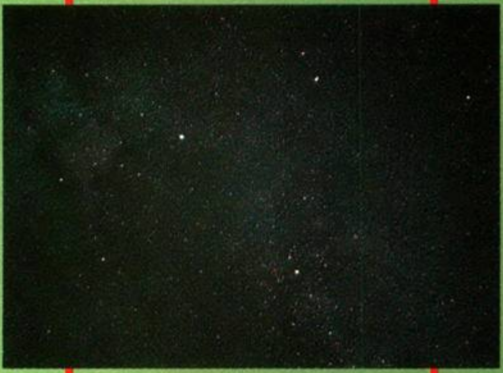
REMARKABLE RECORDING POWER made ScotchChrome 400 the winner of the October 1992 film test. It recorded red nebulosity extremely well, requiring half the exposure of Ektachrome, but had a strong magenta cast. Provia and Ektachrome, even at ISO 1600, are finer grained and sharper than ScotchChrome 400 at ISO 800.

PIGGYBACK

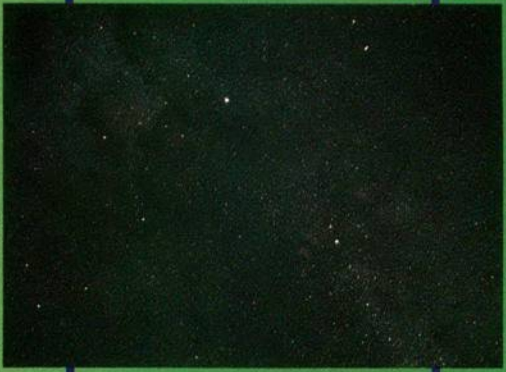
FRAMES AT ISO 1600

FRAMES AT ISO 800

THE LOW CONTRAST, low red sensitivity, and strong cyan cast to the sky seen in prime focus shots still distinguished Provia 1600 shot through a 105mm telephoto at f/2.5 for shorter exposure times. For exposures under 30 seconds, it worked well for aurora and constellation shots. But this new film did not fare well in any long-exposure test on typical astrophoto targets.



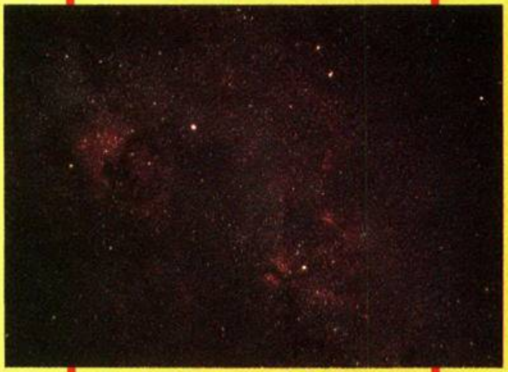
4 min. at f/2.5



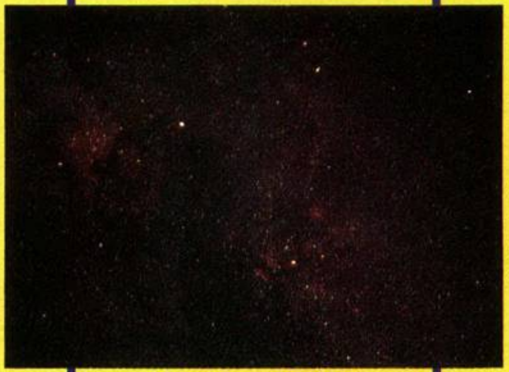
8 min. at f/2.5

Fujichrome Provia RSP

RED NEBULOSITIES stood out clearly from a dark and neutral sky in piggyback tests of Ektachrome P1600. This film shot at ISO 1600 for 4 minutes produced similar results as exposures at ISO 800 for 8 minutes, with the faster shots having a grayer sky and coarser but not objectionable grain. For the best results, push this film only to ISO 800.



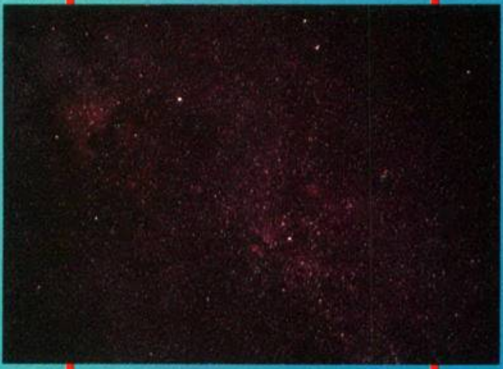
4 min. at f/2.5



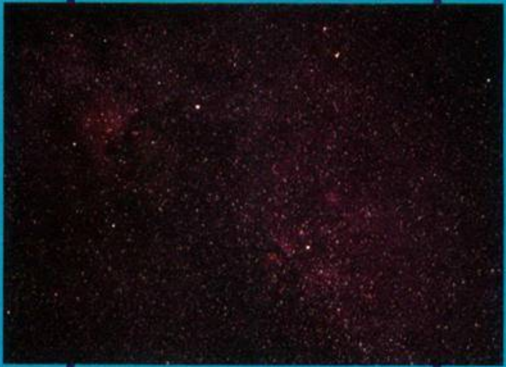
8 min. at f/2.5

Ektachrome P1600 EPH

USING EXPOSURES ONLY HALF AS LONG, ScotchChrome showed the same amount of nebulosity as seen in the Fuji and Kodak frames above. Exposure times the same length as for the frames above yielded a bright, washed out sky. Of the three, ScotchChrome appeared to have the most freedom from reciprocity failure.

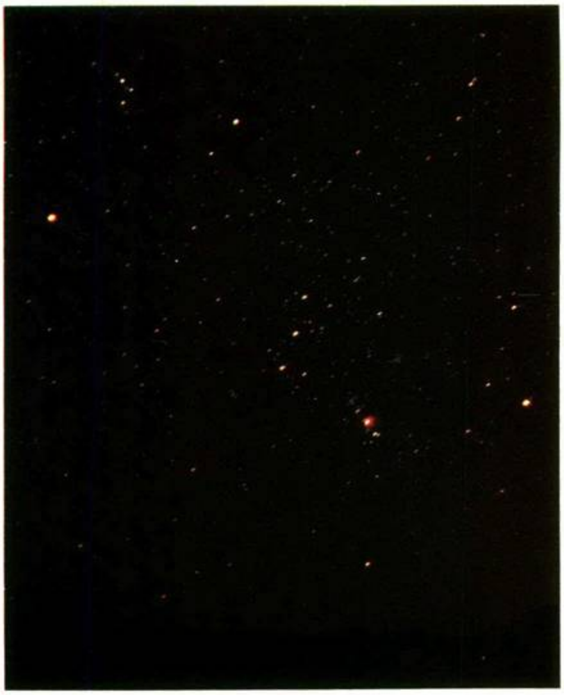


2 min. at f/2.5



4 min. at f/2.5

ScotchChrome 400



A SHORT 30-SECOND SHOT on Ektachrome P1600 with a fixed camera picked up Orion's faint Horsehead Nebula and the arc of Barnard's Loop.

FUJI PROVIA 1600 works well for short-exposure subjects such as aurorae. The film's green response works to its advantage in this case.

Testing the Films

The only fair way to compare the performance of the three ultrafast films was to shoot the same subject with the same equipment on the same night. The dark-of-the-Moon night in October 1994 I selected was clear and transparent but plagued by an aurora and airglow. While the sky was not as dark as I would have liked, the films were at least subjected to the same sky conditions.

For targets I chose the nebulosities of Cygnus, a good test for critical red sensitivity. All shots were taken within a 3-hour interval with Cygnus overhead or high in the west. I took two kinds of photos: prime focus shots with the camera placed at the focus of a 4-inch apochromatic refractor with an effective focal length of 450mm at f/4.5, and piggyback shots with the camera and a 105mm, f/2.5 Nikkor telephoto lens riding on a tracking platform.

I shot two rolls of each of the three films, with no hypering or special treatment, one processed at ISO 800 and one at ISO 1600. For each film and film speed, I took an identical range of exposures (only one exposure from each set is shown here).

To test reciprocity failure, I made a 16-minute piggyback shot through a 0.9 ND neutral density filter (sometimes designated a 3-stop or 8x filter-factor filter) to artificially lengthen the exposure. Because the f/ratio and lens aperture remained unchanged, this 16-minute photo should have looked the same as a 2-minute exposure without the ND filter, if the film had no reciprocity failure. But the films were always underexposed compared to the 2-minute exposures. Only ScotchChrome came close to passing this test.

The Results

Ektachrome P1600 proved the overall winner. Its predecessor, Ektachrome P800/1600, had poor red sensitivity and failed to record much nebulosity in previous tests. Not so with this new film: Red nebulosity and Milky Way starfields stood out nicely against a contrasty and neutral sky. This is a dramatically new film. How does it compare with the other two films?

Grain and sharpness. Both the Ektachrome and Provia films proved to be very fine-grained for their speed, with little difference between the two. Even at ISO 1600, both films exhibited finer grain and sharper star images than ScotchChrome did at ISO 800 and about equivalent graininess to ScotchChrome processed at ISO 400. When processed at ISO 800, both the Fuji and Kodak emulsions surpassed ScotchChrome at any speed for grain and sharpness. Ektachrome shot at ISO 400 (tell the processor not to push the film) is fine-grained and is suitable for shooting fixed camera and piggyback shots with fast lenses (f/2 or f/2.8).

Suggested Exposure Times

3M ScotchChrome 400

At ISO 800	Moderately Dark Sky	Very Dark Sky
f/2.0	4 minutes	6 minutes
f/2.8	8 m	12 m
f/4.5	24 m	40 m
f/6.0	50 m	80 m
At ISO 1600	**Moderately Dark Sky**	**Very Dark Sky**
f/2.0	2 m	3 m
f/2.8	4 m	6 m
f/4.5	12 m	20 m
f/6.0	24 m	40 m

Kodak Ektachrome P1600

At ISO 800	Moderately Dark Sky	Very Dark Sky
f/2.0	7 minutes	12 minutes
f/2.8	15 m	24 m
f/4.5	45 m	75 m
f/6.0	not suggested	not suggested
At ISO 1600	**Moderately Dark Sky**	**Very Dark Sky**
f/2.0	3.5 m	6 m
f/2.8	7 m	12 m
f/4.5	24 m	40 m
f/6.0	70 m	100 m

NOTE: Cut exposure times by up to half in sub-freezing temperatures or if the sky is bright with light pollution, an aurora, or reflection off snow. When shooting these films "unpushed" at their base speed of ISO 400, double the ISO 800 exposure times.

Red sensitivity. 3M ScotchChrome was still the winner here, but not by much. Ektachrome fared very well, picking up almost as much faint outlying nebulosity as Scotch did. The loser is Provia 1600. As with the old Fujichrome 1600D, the new film barely recorded prominent red nebulosities such as the North America Nebula.

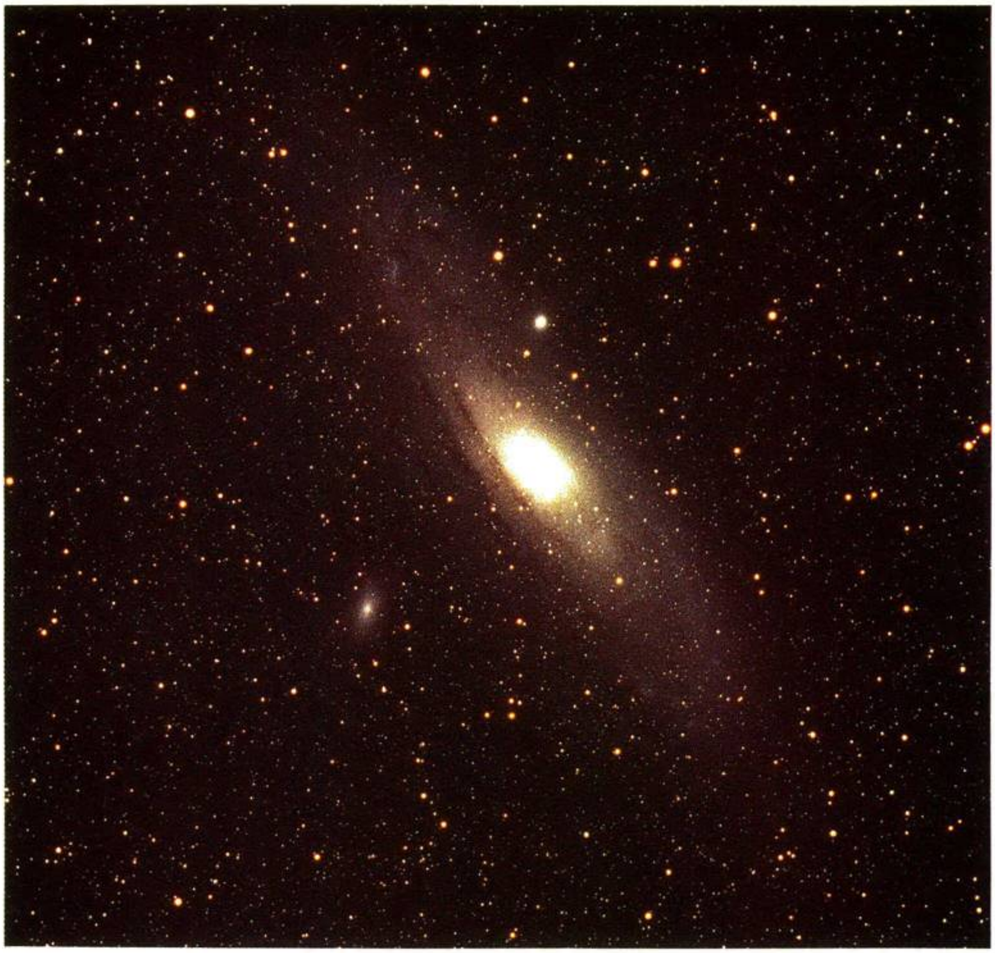
Color cast. Ektachrome came out on top here. Even in a sky brightened with a faint, greenish aurora in the north, it yielded a dark neutral sky background. Provia consistently turned cyan, a result of its lack red sensitivity in long exposures. ScotchChrome consistently turned magenta, in part because of its high red sensitivity.

Reciprocity failure. ScotchChrome was still the winner here. In longer exposures at any ISO rating, ScotchChrome consistently required only half the exposure time as Ektachrome to pick up the same amount of nebulosity. Or to put it another way, the same exposure time that proved best for Ektachrome would overexpose ScotchChrome frames from airglow. Ektachrome exhibited the greatest reciprocity failure of all three films. It held out for 35-minute exposures at f/4.5, but compared to ScotchChrome, it was clearly beginning to fade in recording power. For shots at slower f/ratios requiring longer exposures, I suspect this film may not have enough sensitivity to record faint objects without hypering.

Winter test exposures showed a partial solution to Ektachrome's reciprocity failure. With the film at –10°C, it speeds up the equivalent of about one f/stop, meaning the exposure needs to be only half as long. ScotchChrome also shows this "cold camera" effect. So there is some advantage to suffering during wintertime shooting!

Pushability. All three films pushed well, exhibiting a noticeable but not objectionable increase in grain at ISO 1600. At this speed, all showed a grayer background and less contrast between object and sky. But as the test shots show, at ISO 1600 each film took only half the exposure time to record the same amount of nebulosity as it did at ISO 800.

Although not included in this test, I have also shot test rolls of Kodak's Elite 400 and Fuji's Provia 400, but neither film came close to Ektachrome P1600's performance. Elite 400 has only moderate red sensitivity while Provia 400 lacks any and also turns cyan in long exposures.



EKTACHROME P1600 SHOWS ITS STUFF on the Andromeda Galaxy, recording good detail with neutral color balance in this 25-minute exposure at f/4.5 and pushed two stops to ISO 1600 speed.

Recommendations

With the introduction of its new Ektachrome P1600, Kodak has added a powerful new film to the astrophotographer's arsenal. At last we have an improved film that actually works better than its predecessor for photographing the night sky. This is probably the single best slide film for camera-on-tripod constellation photos, nightscape scenic shots, guided piggyback shots, and most prime focus work. Its principal drawback is its reciprocity failure limiting its recording power in exposures over 30 minutes or so.

As a result, if you are shooting at f/6 or slower and want to avoid the hassle of hypering films, use ScotchChrome 400. But keep in mind it is relatively coarse-grained and can turn magenta under all but the darkest sky conditions. This film is also very sensitive to poor processing. Exhausted chemicals at your local 1-hour lab will kill Scotch's amazing red sensitivity. 3M recommends using only a high-volume lab that maintains high standards in its chemistry and processing techniques.

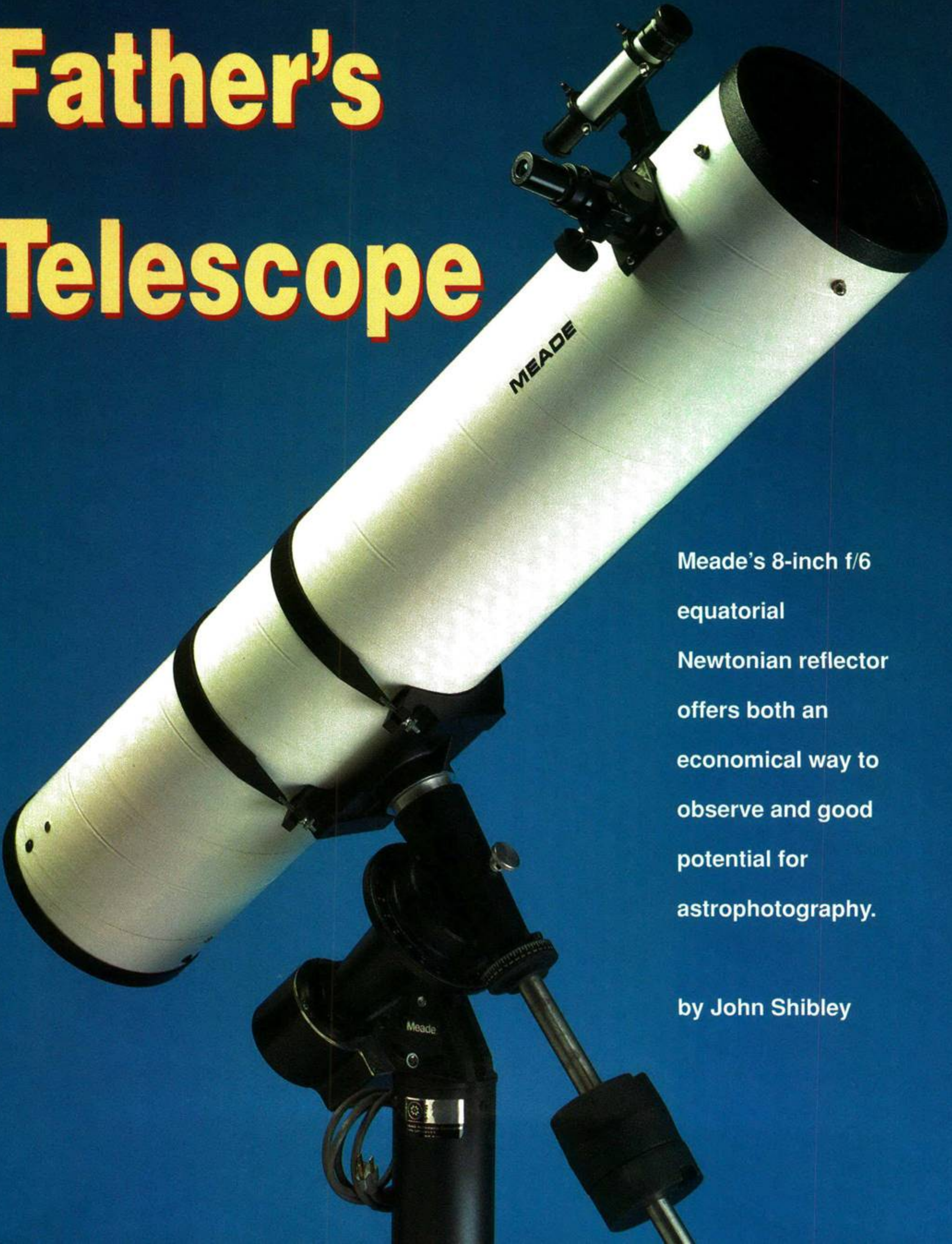
As for Fuji Provia 1600, this film will serve for short (20-second) constellation shots and aurora photos. But for long deep-sky exposures, stay with Ektachrome P1600 or ScotchChrome 400. With these two films, by all means shoot at ISO 1600 if you need to keep exposure times to a minimum. But for the sharpest, most contrasty results shoot at ISO 800 or even 400.

The ready availability of a superb slide film such as Ektachrome P1600 opens up astrophotography to everyone. Great photos needn't be the private reserve of only those with access to special hard-to-get films or those who can practice the black art of hypersensitizing film.

Bravo Kodak! Now just don't "improve" the film! ☐

Alan Dyer is a program producer at the Alberta Science Centre in Calgary, Alberta. He coauthored the book The Backyard Astronomer's Guide *with Terence Dickinson.*

This Is Not Your Father's Telescope



Meade's 8-inch f/6 equatorial Newtonian reflector offers both an economical way to observe and good potential for astrophotography.

by John Shibley

It was the quintessential telescope of your father or grandfather's day: the classic, economically priced Newtonian, with its long white tube and German equatorial mount. That staple instrument of yesteryear seems eclipsed today by increasingly popular Dobsonian telescopes and ubiquitous Schmidt-Cassegrain outfits. Yet the affordable Newtonian design still lives, filling a niche between the former, which can't track with the sky, and the latter, which costs upward of $2,000.

While a number of companies market Newtonians in and beyond the price range of Schmidt-Cassegrain telescopes, a handful still offer moderate-aperture, budget-priced Newtonians with equatorial mountings. The 8-inch f/6 Meade Starfinder Equatorial has features useful to both deep-sky and planetary enthusiasts. Its focal ratio retains the flexibility of wide-field observing without sacrificing higher power for lunar and planetary observing. Because of its clock-driven equatorial mount, the telescope tracks with the sky, eliminating the need for constant bump-and-nudge recentering. Its 8-inch aperture reaches down to magnitude 13.3 while theoretically resolving 0.6 arcsecond details. And with a few accessories and modifications, the Starfinder can be used for astrophotography. All this for a sticker price of around $800, which includes shipping.

Arrival and Assembly

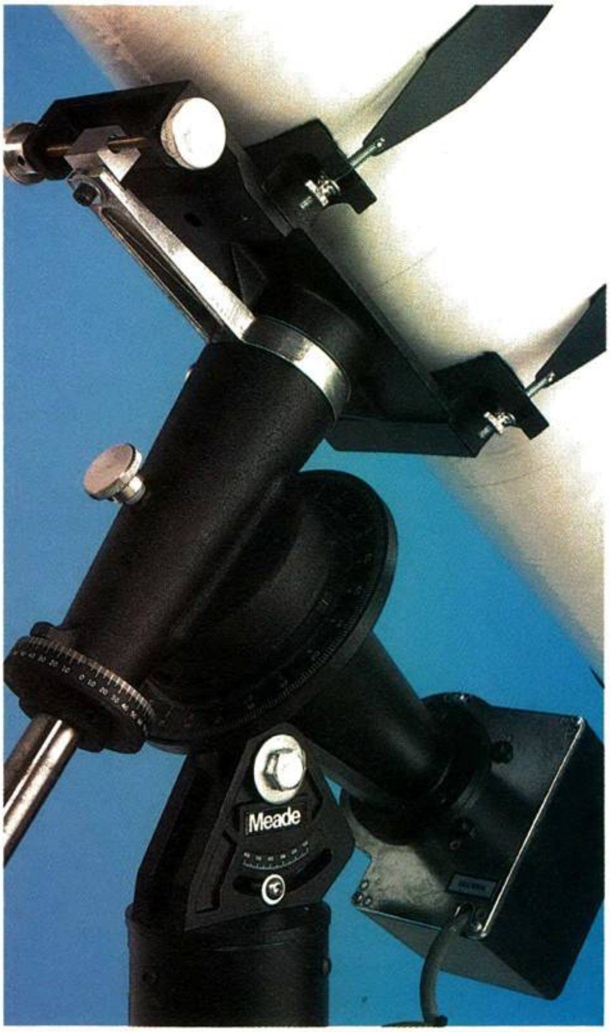
The Starfinder Equatorial ASTRONOMY tested was pulled from Meade's inventory and shipped in four parts: the mount and legs in one box, the optical assembly in another, and two counterweights packed in separate boxes.

Assembling the mount and pier is straightforward. Three legs attach to the pier with wing nuts. Two flexible metal straps bolt to the mount's saddle plate, which secures the optical tube. Two counterweights (one 10 pounds, the other 5) slide onto the declination shaft, held in place by hex socket set screws. In case the weights slip, a retaining washer at the end of the shaft prevents them from falling to the ground.

After unpacking the optical tube assembly box, you install the mirror cell (in which the mirror is already mounted) in the tube and then attach the 1¼-inch focuser and a 6x30 finder scope. The tube's back end has two sets of three holes that accept the mirror cell: One set, placed farther back on the tube, holds the cell for general observing. The second set, a few inches forward, holds the cell for prime focus photography. (This forward position fully illuminates a camera's 35mm x 24mm field.) Metal plugs in the mounting holes punch out before you use hex screws to secure the cell inside the tube. Both the focuser and finder go on the tube's front end, held in place with nuts and bolts. The secondary mirror and its mount is installed at the factory.

Before placing the tube on the equatorial mount, loosen a hex bolt where the declination axis pivots in altitude. Align the bolt with a scale on the mount (printed in 1 degree increments) so its position reads the same number as your latitude and then tighten. This aligns the declination axis with your latitude, which is essential for allowing the equatorial mount to track objects as they move across the sky.

Now all the elements of the Starfinder come together. The optical tube sits on the mount's saddle, held in place by two metal straps. Strap ends slide into slots on the mount and tighten with thumb nuts. Loosening the nuts allows the tube to turn and position the focuser for more convenient viewing. Loosened straps also let the tube slide forward or back for proper balancing. When loosened enough, the straps slip out of their slots, allowing you to completely remove the tube from its mount for separate storage.



BLACK TUBE STRAPS SECURE the telescope to its mount; brass hand knobs tighten the straps. A silver arm with knobs seen below the saddle is the optional tangent arm, which provides manual slow-motion control for the declination axis. On the mount proper is the declination lock knob. To the right and below it is a latitude scale and locknut. The box in the lower right houses a clock drive motor.

Materials and Quality

The Starfinder equatorial mount, painted flat black, is made of cast iron and machined steel components and weighs 34 pounds without counterweights. Its declination axis has a knob that hand-tightens to secure, but not lock, the axis. A Teflon tip presses against the steel shaft but doesn't score it. This allows you to move the scope slightly in declination without having to reach around the tube to completely unlock the knob. An optional tangent-arm assembly ($78) provides manual slow-motion for declination.

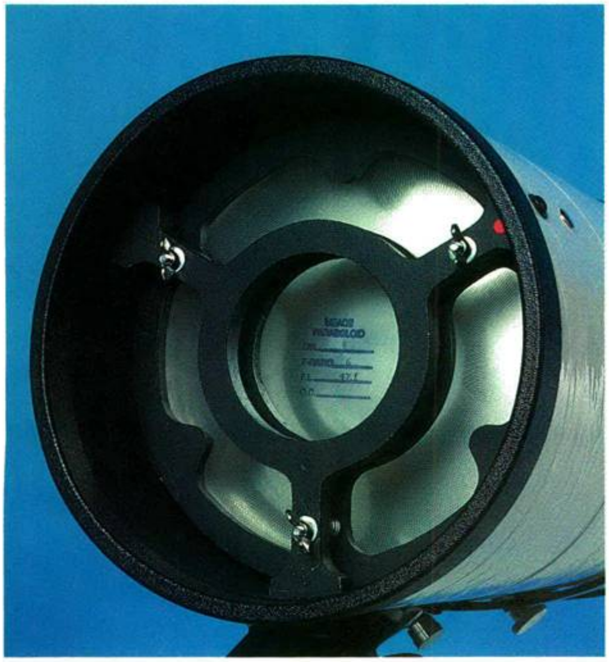
To automatically move with the sky, the right ascension axis has an electric clock drive that runs off 120 volt AC house current. A slip clutch allows positioning the scope in right ascension by hand without disengaging the motor. The axes have etched scales for declination (1° increments) and right ascension (5 minute increments). There are no vernier scales provided for finer accuracy.

The Starfinder's 4-foot-long optical tube (15 pounds) is of compressed cardboard painted flat black on the inside, with an exterior tightly wrapped in a spiral fashion with white vinyl tape. Though the tape increases tube rigidity and durability, it makes for a tube surface that isn't smooth; trapped air bubbles between layers are noticeable.

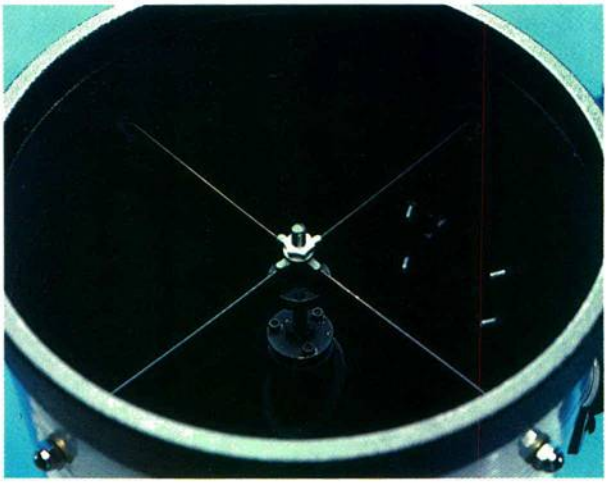
Another drawback of the cardboard tube is that its accessory holes in the tube might fray with repeated use, such as when relocating the mirror cell between its general observing and optimized photography mounting points. If you anticipate frequently relocating the mirror for different applications, line the holes with an epoxy glue to prevent fraying.

The Starfinder's 1¼-inch focuser is plastic with a metal rack-and-pinion mechanism. It has a two-inch travel that accommodates a wide variety of eyepiece designs. After several observing sessions, the focuser developed a small but noticeable amount of play that, despite some improvement after retightening the rack-and-pinion housing, never completely went away.

While this focuser performs admirably over a wide range of observing, astrophotographers might want to consider installing a beefier focuser, perhaps one that even accepts 2-inch eyepieces, available from Meade or a whole host of third-party suppliers.



STARFINDER'S PRIMARY MIRROR CELL attaches to the tube just forward of a black tube ring. A metal punch-out tab marks the attach point for astrophotography.



THE SECONDARY MIRROR SITS in a four-vane "spider" mount. A center post adjusts the mirror up and down and rotates it. Hexhead collimation screws on the back of the cell provide fine alignment.

At the Starfinder's heart is a full-thickness (1⅜ inch), 8-inch f/6 mirror made of low-expansion Pyrex glass, housed in a two-piece aluminum mirror cell. The housing that holds the mirror is separated at three points from a plate that attaches to the tube. Compressed springs around the posts at those three points provide tension when the mirror is adjusted during optical alignment, done with wing nuts that stick out of the back of the cell.

The telescope's 1.5-inch minor axis-diameter secondary mirror is housed in a cell supported in the telescope's tube with four vanes. This mirror cell pivots left and right by loosening a nut and turning the cell's support bolt. Three hex socket head screws move the secondary mirror in its cell for fine collimation.

Though Meade says it collimates the Starfinder's optics in-factory, the scope I tested needed adjustment. The manual includes step-by-step instructions on how to collimate the telescope. Collimating the main mirror was quick and easy, but the secondary's tilt screws were coated in black paint, which first had to be removed before alignment. After collimation (which took 10 minutes the first time I did it), the scope held alignment remarkably well, considering the jostling it took getting in and out of the garage between observing sessions.

Observing and Beyond

I tested the Starfinder on three separate evenings in temperatures ranging from 15° F to 45° F. Optically, the scope performed beautifully. Detail on the First Quarter Moon was sharp and displayed excellent contrast. Later in the month, when the Moon was out of the way, I enjoyed wispy tendrils in the Orion Nebula and resolved six members of its Trapezium star cluster.

To get you started in observing, the Starfinder comes with a 25mm Modified Achromatic eyepiece that yields a power of 48 and a 50 arcminute (just under 1°) field of view. This serves as a basic low-power eyepiece; two more eyepieces with focal lengths in the 7mm to 10mm and 13mm to 17mm range would serve to round out an ideal collection.

To test the mirror's figure I examined out-of-focus

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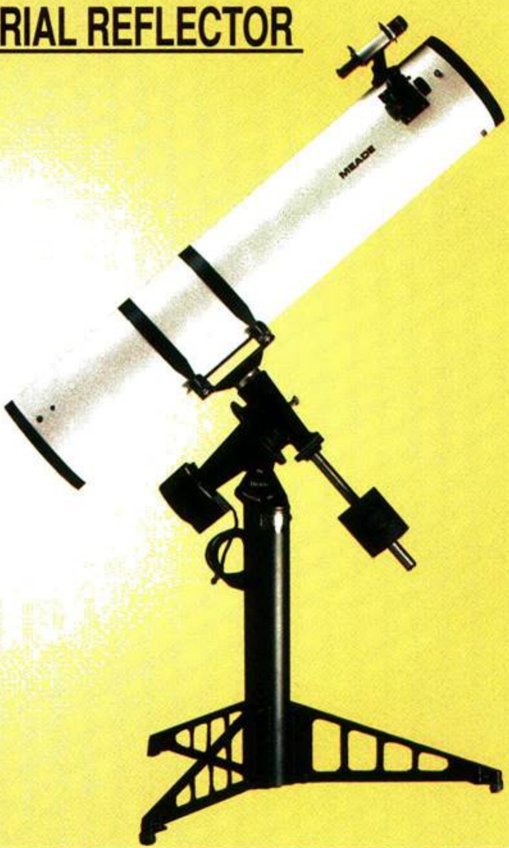

Standard specifications

Aperture	8 inches
Focal ratio	6
Primary mirror thickness	1$^{3}/_{8}$ inches
Secondary size (minor axis)	1.5 inches
Secondary obstruction (by diameter)	19%
Size of focuser	1$^{1}/_{4}$-inch
Standard eyepiece	25mm Modified Achromatic
Finderscope	6x30
Total telescope weight (including mount)	64 lbs.
Weight of heaviest component (mount with counterweights)	49 lbs.
Typical selling price	$700
Cost of shipping	$75
Promised delivery time	30 to 60 days

Optional accessories

#55 slow motion declination control	$78
#47M dual-axis drive corrector (includes #55)	$399
#43 right ascension axis drive corrector	$129

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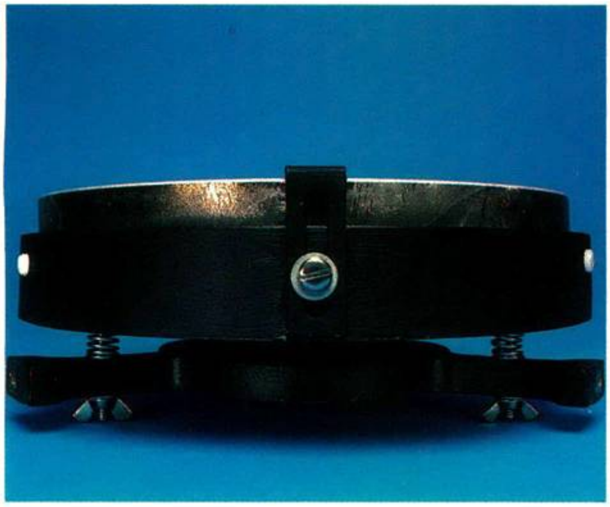
images on either side of a bright star's perfect focus, using a 7mm Televue Nagler eyepiece that gave 171x. At high power, just out of focus, a star's image breaks into a series of concentric rings. If the rings are perfectly spaced and appear identical inside and outside of focus, the optics are perfect. If they seem distorted, the optics still need alignment or some other optical defect may be present (see "Test Your Scope's Optics," July 1994).



CLIPPED INTO ITS CELL, the primary mirror is supported on a mounting plate at three points by spring-surrounded posts. Wingnuts adjust spring tension, tilting the mirror cell during optical collimation.

When I compared the rings on either side of focus for the Starfinder's mirror, I detected an ever-so-slight intensity difference in the inner ring. This suggests that the mirror I evaluated has a tiny amount of spherical aberration. Being able to detect such a minute flaw is more a testament to the power of star testing; images in focus, for all intents and purposes, still looked very sharp.

The Starfinder's equatorial mount is beefy and seems more than adequate to support the 8-inch scope. Even with rough polar alignment, the mount's clock drive kept an object in the field of view of a 13mm Televue Nagler eyepiece (92x, 53' field of view) for more than 10 minutes. Rapping the tube at this power created vibrations that took 3 to 5 seconds to dampen out. After moving to another object in the sky, I detected a 4 arcsecond drift until the clock drive's worm gear took over moving the scope.

As a visual scope, the Starfinder 8-inch f/6 is fun to use and performs well as a deep-sky and lunar scope. With an upgraded focuser and a dual-axis drive corrector, it would also be an ideal scope for a first deep-sky astrophotography rig. One bonus this Newtonian holds for astrophotographers is its long tube; there's plenty of room for a decent-sized guide scope or equipment for piggyback photography.

Combined with its potential and a cost of less than $800, the 8-inch f/6 Starfinder Equatorial Reflector proves that an "old-fashioned" Newtonian reflector, the progenitor of most telescope designs on today's market, still holds plenty of promise for the observer and photographer of the 1990s. □

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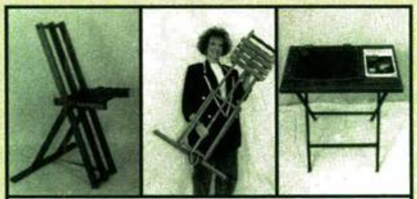

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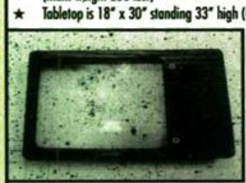

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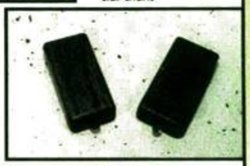

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8.6"-10.5"	127.00	97.00	166.00
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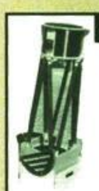

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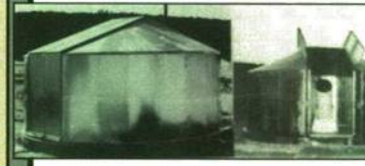

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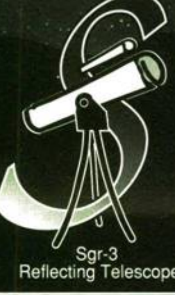

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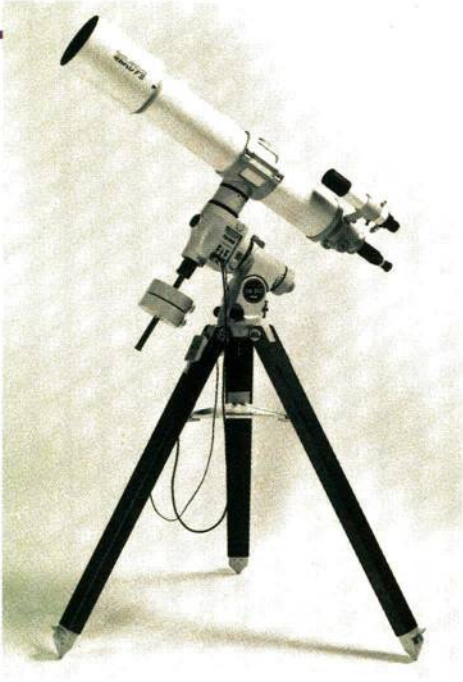


New Takahashi Refractor

The Takahashi FS-128 apochromatic refractor has a 5.1-inch f/8.1 doublet fluorite objective with a focal length of 1,040 mm. The tube is 46" long, weighs 16½ pounds, and incorporates 10 internal knife-edge baffles. Buyers can purchase the tube assembly separately or in a package that includes the EM-200 all-electric equatorial mount, a wooden tripod, 7.5mm and 18mm eyepieces, and a diagonal prism in which eyepieces twist-lock into place.

Texas Nautical Repair, 3110 S. Shepherd, Houston, TX 77098, (713) 529-8480. FS-128 tube assembly (item TSK1281): $4,975; complete package (TSS1032): $8,345.

Rugged Binoculars

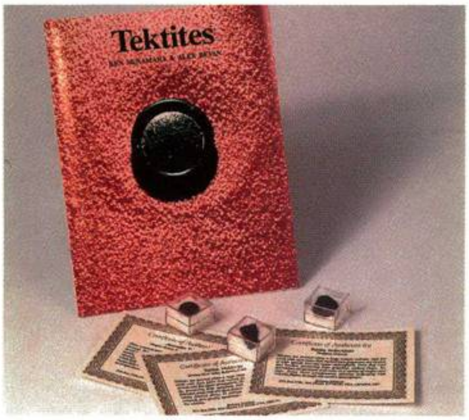
These 7x40 binoculars were manufactured by Carl Zeiss-Jena to Warsaw Pact specifications for use by border guards along the East German frontier. They feature extra-low-dispersion glass and are weatherproof with rubber armor. Built into the optics is a rangefinder reticle with tritium illuminator. The binoculars come with English instructions and carry a lifetime guarantee.

Sunset Cliffs Merchandising Corporation, P.O. Box 7518, San Diego, CA 92167, (800) 225-9407. $499.

Tektite Kit

The tektite kit from Bethany Sciences has three tektite specimens in clear gemstone boxes: an australite, a moldavite, and an indochinite. Each specimen comes with a certificate of authenticity. The kit includes the book *Tektites* by Ken McNamara. Bethany also offers a catalog of meteorites and tektites.

Bethany Sciences, P.O. Box 3726-A4, New Haven, CT 06525-0726, (203) 393-3395, fax (203) 393-2457. Tektite Collecting Kit: $43.95 plus $4.95 shipping and handing; meteorite catalog: $2.



This department presents new product announcements issued by manufacturers. Product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers should send announcements and color photographs of their products to the attention of John Shibley.

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Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
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40mm to 80mm Binoculars - Mounted .... $92.00 pr.

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Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	129.00
11"	149.00	11"	139.00
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40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS (Full Aperture) Type 3

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
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5"	349.00	5"	339.00
6"	399.00	6"	389.00

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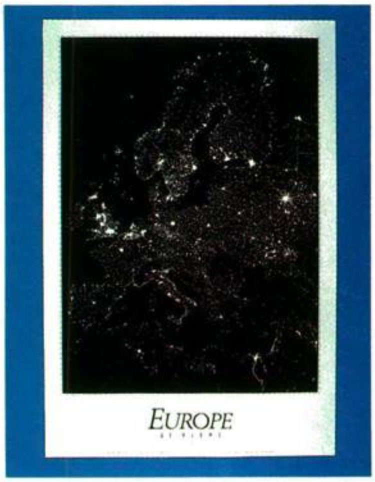
Celestron, 2835 Columbia Street, Torrance, CA 90503, (310) 328-9560, fax (310) 212-5835. 12x80 (# 71010 12x80): $770; 20x80 (#71011): $820.



Europe at Night Poster

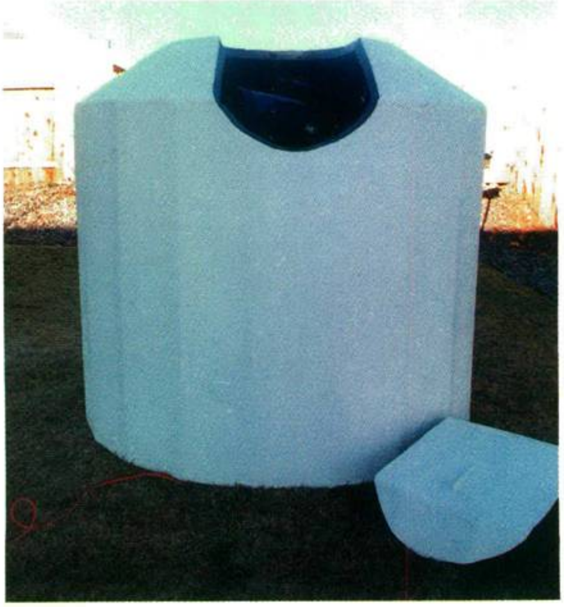
This 24" x 36" color poster sold by the Hansen Planetarium is a composite of several photos taken by Air Force weather satellites in 500-mile-high polar orbits. It shows all of Europe at night and covers an area from northern Scandinavia to North Africa. Besides capturing city lights, the images show oil fires burning in the North Sea and in the Middle East. The poster comes with a key to cities and explanatory notes. Available in paper and laminated versions.

Hansen Planetarium Productions, 1845 South 300 West, #A, Salt Lake City, UT 84115-1804, (800) 321-2369, (801) 483-5400, fax (801) 483-5484. Paper: $7 plus $4 postage; laminated: $14.50 plus $4.75 postage.

Portable Styrofoam Dome

California observer Vance Hurd is selling plans for his Styrodome, a 10' by 6' styrofoam dome built for under $250 from easily obtained materials that weigh less than 50 pounds. Hurd mentions that his dome has kept his 10-inch Schmidt-Cassegrain telescope protected through one winter, two hail storms, and winds of over 50 miles per hour. The Styrodome kit includes plans, parts list, instructions, and construction pictures.

Vance Hurd, 2263 Everest Drive, Redding, CA 96001, (916) 244-2159. $25 (California residents add 6% sales tax).



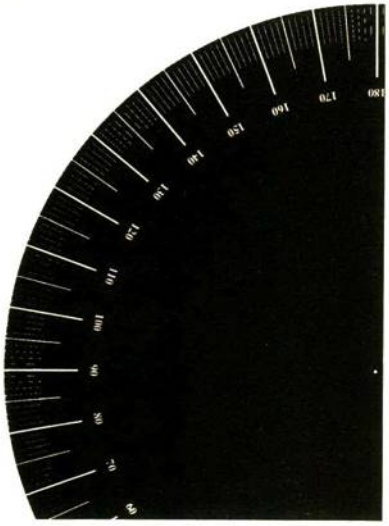
Make Circles for Your Dob

We don't normally print computer programs in AstroBytes, but this is a nifty little program that complements the recent article "Add Circles to Your Dob" (part of "Improving Your Mount, pp. 66-67, December 1994). Jack Jones of Murray, Utah, read the article, but didn't want to buy a compass just so he could photocopy its rose. Instead, he wrote this PostScript program that will print a 7-inch diameter circle marked off in degrees.

When typing this program in, save it as an ASCII text file, and then send it to a PostScript printer using a PostScript driver such as *GhostScript* or *Downloader.* Or type the program using a word processor such as *WordPerfect* or *Microsoft Word,* convert the document to PostScript style, and print the circle directly from the word processor. Adjust the circle radius to match that needed for your Dob by changing the number inside the brackets in line 13. The circles print white lines on black, but you can reverse that by setting bgshade to 1 and fgshade to 0 in lines 14 and 15.

```
%%%%%%%%%%%%% begin postscript program %%%%%%%%%%%%
%!PS-Adobe-3.0 EPSF-3.0
%%BoundingBox: 0 0 612 792
%%Title: (Compass)
%%Creator: (Jack W. Jones)
%%Creationdate: (11/16/94)
%%Pages: 1
%%Version: 2.0 0
%%EndComments

%%BeginProlog
%Constants
/radius {3.5 inch} bind def        %Radius of protractor
/bgshade 0 def        %0=black, 1=white
/fgshade 1 def
/fntsize 8 def              %Font size
/PC {4.25 inch 5.5 inch} def    %Center of page

%General Use Variables
/inch {72 mul} bind def
/center {dup stringwidth pop 2 div neg 0 rmoveto} bind def

%Fill a circle
/fillcircle {0 0 3 -1 roll 0 360 arc closepath fill} def

%Draw lines from the center
/radiate {dup 360 exch div cvi {0 0 moveto 0 radius lineto
             stroke dup rotate} repeat pop} def
%%EndProlog

%Translate coordinates to center of page
PC translate

%Make a shaded circle
bgshade setgray
radius fillcircle

%1 degree tic marks
gsave
             .1 setlinewidth fgshade setgray
             1 rotate 1 radiate
grestore
bgshade setgray radius dup .1 mul sub fillcircle

%5 degree tick marks
gsave
             .5 setlinewidth fgshade setgray
             5 rotate 10 radiate
grestore
bgshade setgray radius dup .15 mul sub fillcircle
```

Setting circles are easy to make on a PostScript printer.



NOTICE

Please be advised that any person or company making claims that they were once affiliated with the world's largest solar filter manufacturer, Thousand Oaks Optical, and that their filters offer an identical view, is not true. The person making these claims was employed as a part-time assembler for Thousand Oaks Optical. We hereby disavow any responsibility for the **safety** and quality of their product, nor should it be construed that it's the same as ours. For the past fifteen years the product safety and reputation of glass solar filters has been achieved by the owner of Thousand Oaks Optical.

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```
%10 degree tic marks
gsave
            1 setlinewidth fgshade setgray
            10 radiate
grestore
bgshade setgray radius dup .2 mul sub fillcircle

/Times-Bold findfont
fntsize scalefont
setfont
fgshade setgray
gsave
            0 10 350 {
                        gsave
                                    0 radius dup .2 mul sub fntsize sub translate
                                    180 rotate 0 0 moveto
                                    3 string cvs center show
                        grestore
                        -10 rotate
            } for
grestore

%Make a center dot
fgshade setgray
1 fillcircle

showpage
%EOF
%%%%%%%%%%%%%%%%% End postscript program %%%%%%%%%%%%%%
```

SkyLights

Zephyr Software, 1900 Murray Avenue, Pittsburgh, PA 15217, orders (800) 533-6666, information (412) 422-6600, fax (412) 422-9930. Price: $89.95. Minimum requirements: IBM PC-compatible computer, Windows 3.1, and a hard disk with 1 MB of free space. The program's author also recommends a mouse and a math coprocessor.

SkyLights is a planetarium-type program that lets the user view the sky from any location on Earth from 4713 B.C. to A.D. 9999. It displays all the planets, the Sun, the Moon, about 1,600 stars down to 5th magnitude, and 400 deep-sky objects selected from the *New General Catalogue* and the *Index Catalogue*. Setting an observing site is as simple as selecting a choice from the database of cities (users can add to this list and edit it), clicking on a world map, or entering the site's latitude and longitude.

Users can choose between local time and Universal Time and between Julian date or Gregorian calendar date. For accurate rise and set times of objects, the program accounts for the observing site's elevation, atmospheric pressure, and temperature. A companion program called *TZSet* enables *SkyLights* to calculate Universal Time from the computer's clock. Clicking on an object provides the object's right ascension, declination, altitude, azimuth, distance, brightness, and rise and set times. Another box provides information about the coordinates of the center of the display. This box also includes the Sun's altitude above or below the horizon, which is handy for determining how long an object can be observed close to sunrise. Because of the Windows interface, users can drag these information boxes anywhere on the screen so they don't hide important parts of a map.

A tracking feature allows the user to watch eclipses of the Moon and Sun, occultations of stars as they pass behind the Moon, or the path of a planet across the sky. Users can save the settings for a particular celestial event for redisplay later. A selection of saved events comes with the program.

Sky maps can display one of four grids: right ascension and declination, altitude and azimuth, ecliptic latitude and longitude, or galactic latitude and longitude. Users can select either equatorial maps or horizon views, and the background sky color is adjustable. Finding the angular distance between two points is easy: Click the right mouse button and drag the mouse between the points.

A slider bar enables users to zoom in and out on a sky map. Don't know where to find an object? A search feature will locate it automatically. For beginners, a tutorial steps through the basic features of *SkyLights*. ☐

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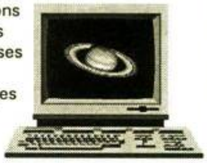

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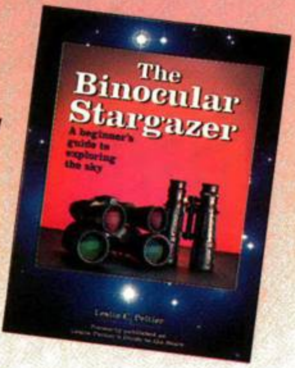

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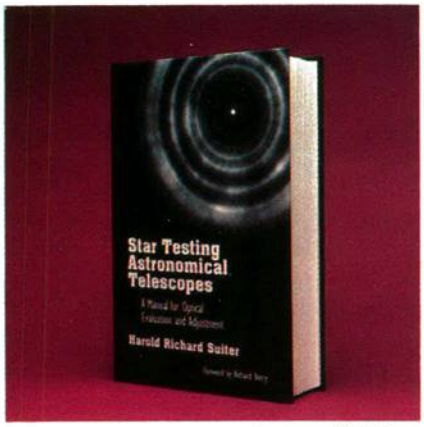
Star Testing Astronomical Telescopes

Harold Suiter, (Willmann-Bell, 1994), ISBN 0-943396-44-1, 364 pages, hardcover, $24.25.

Tonight's the night. That $800 telescope you've been waiting for has finally arrived. After excitedly setting it up, you center Jupiter in the eyepiece. Excitement builds. You focus and focus again, switch eyepieces, focus again. The view is horrendous! What's causing it? Is it just unstable atmospheric conditions or are the telescope's optics out of alignment? Is it heat rising off the asphalt parking lot you're observing on or is the telescope too warm? Or, horror of horrors — it could be that your new mirror is not up to specifications. And what kind of flaw is it? Rough surface? Spherical aberration? Astigmatism?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A Manual for Optical Evaluation and Adjustment
Harold Richard Suiter

ASTRONOMY: Darla Evans

Far too many of us have experienced this disturbing scenario. But now, thanks to *Star Testing*, you can answer these questions easily and probably have the telescope operating in no time. And if there is an optical problem, you will be able to communicate it clearly to the dealer and get prompt action.

What is star testing? Simply the art of looking at a star's focused and defocused images to determine if the telescope's optics perform perfectly, and if it doesn't, why doesn't it? Gleaning and interpreting clues yielded by star testing allows a diagnosis of virtually any problem that can afflict a telescope. Amazingly enough, before this book came along, no detailed account existed on how to star test.

One strength of the book is that there is something for everyone — although the technical details could be intimidating to some at first glance. Chapters one and two explain basic optics in a fashion that any motivated beginner can follow. Computer-generated illustrations of defocused star images are so realistic that you can learn a great deal by just looking at the pictures. Chapters three and four describe optical principles that may be difficult for some readers to follow, but fortunately these chapters are not necessary for basic star testing. Chapter five offers a step-by-step description of star testing, again written so that most beginners can follow along. This chapter ends by describing test sessions with three different telescopes: an 8-inch SCT, a refractor, and a Dobsonian reflector.

Topics in the remaining ten chapters include how to make an artificial star for daytime testing, how to collimate, how to recognize and eliminate "tube currents," how to diagnose and correct problems with mirror cells or lens cells, and how to recognize different aberrations that afflict lenses and mirrors. The book's appendices introduce methods for quantitative testing of optical quality and mathematical details for people so inclined. (If you want to do your own simulations, there is IBM/PC software developed for this book available from Willmann-Bell.)

Star Testing is bound to have a big impact on our hobby: Harold Suiter wants to help buyers assess optical quality so that it plays a larger role in purchasing decisions. This, he feels, will give manufacturers added incentive to produce superior products. In my opinion Suiter will succeed — if enough of us buy this book and read it. Its cost of $24.95 is a small price to pay for becoming an informed consumer. — *Lew Haberly*

More New Books

Observing Comets, Asteroids, Meteors, and the Zodiacal Light

Stephen J. Edberg and David H. Levy, (Cambridge University Press, 1994), ISBN 0-521-42003-2, hardcover, $29.95.

There are several books on how to observe the *Moon, Sun, planets* and deep-sky objects, but what about "the leftover stuff" (as the authors call it in the preface)? To David Levy (of comet-crash fame) and Stephen Edberg (a contributor to ASTRONOMY) this book fills a void and serves as a guide to solar system debris.

Targets are treated in separate chapters that take the reader from beginning observations through more advanced projects such as photography and spectroscopy. Each chapter begins with an overview of an object's physical nature and a synopsis of historical observations.

Bookending these single-subject chapters is general advice on observing (Chapter 1) and a deeper treatment of advanced projects like reducing observational data and doing photometry (Chapter 7). Appendices include report forms, a glossary, a list of meteor streams, and a complete bibliography.

Because of this breadth, *Observing Comets, Asteroids, Meteors, and the Zodiacal Light* is useful to beginning and advanced observers alike.

Between Copernicus and Galileo

James M. Lattis, (University of Chicago, 1995), ISBN 0-226-46929-8, 311 pages. Hardcover, $54; softcover, $17.95.

Christoph Clavius (1538 -1612) was a Jesuit astronomer during a revolution in universal perspective. His astronomy textbooks taught university students of the day that Earth occupied the center of the universe, an idea that was a cornerstone in the Ptolemaic theory.

Because of his prominent scientific standing, in 1611 Clavius, at age 73, was called upon to defend this idea against telescopic evidence Galileo had garnered, which endorsed the Copernican theory that the Sun was the center of the universe. History remembers Galileo as a winner, while Clavius is largely forgotten.

Why then should we read about at Clavius? Because his life is a window into the scientific thinking of the time. *Between Copernicus and Galileo* looks at Clavius' professional life, Ptolemaic theory, and how Clavius successfully defended it against other long-forgotten rival cosmologies. The central purpose of the book is to examine in what ways Copernican theory challenged the Ptolemiac model and how Clavius interpreted Galileo's observations. Most refreshingly, this examination of Clavius' life and his science conveys a vital facet of the Copernican revolution. ☐

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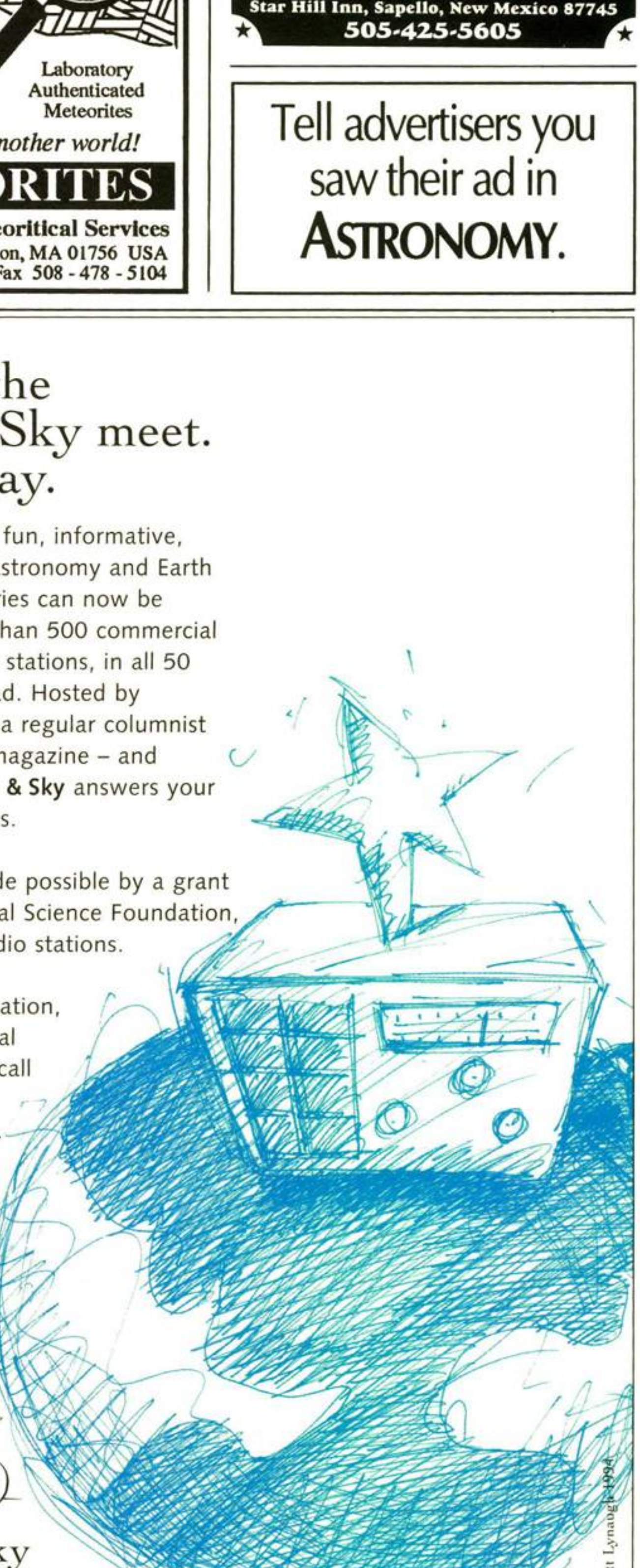

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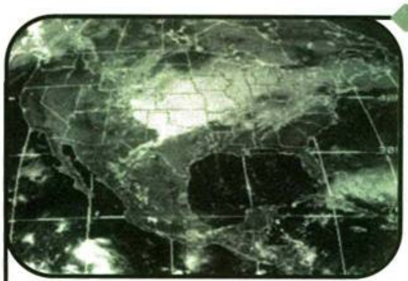

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Pre-registration advised. Contact: Universe '95,
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MEETINGS & EVENTS

May 6
Astronomy Day, Boston, Massachusetts. Contact Noreen Grice, Boston Museum of Science, Boston, MA 02114, (617) 589-0270.

May 6
Astronomy Day, Cranford, New Jersey. Contact A. P. Witzgall, 5204 Tonnelle Ave., North Bergen, NJ 07047-3035.

May 6
Astronomy Day, Rhode Island. Contact C.O.R.I., P.O. Box 2571, Providence, RI 02906, (401) 737-1209.

May 6
Astronomy Day, Virginia. Contact Marta Krause, 2520 Rocky Branch Rd., Vienna, VA 22181, (703) 281-9049.

May 6
Family Astronomy Day, New York. Contact Custer Institute, Main Bayview, Southold, NY 11971, e-mail starwatchr@AOL.com, (516) 765-2626.

May 18-21
Intern'l Space Development Conference, Cleveland, Ohio. Contact Jim, 6167 Oakwood Cr., North Ridgeville, OH 44039-2663.

May 24-26
Big Bear Symposium, California. Contact Lee Snyder, P.O. Box 3964, Incline Village, NV 89450, (702) 831-1931.

May 25-27
Astroblast 95, Pennsylania. Contact John O'Hara, ORAS, Two Mile Park, RD #5, Franklin, PA 16323, (814) 677-3972.

May 26-28
Jersey Star Quest V, Sussex, New Jersey. Contact Larry Smith, 361 Stacy Dr., Belle Mead, NJ 08502.

May 26-29
Riverside Telescope Makers Conf., near Big Bear Lake, California. Contact RTMC, 9045 Haven Ave., #109, Rancho Cucamonga, CA 91730, (909) 948-2205.

May 27-30
South Pacific Star Party, Australia. Contact Tony Buckley, P.O. Box 208 Eastwood, N.S.W. 2110, Australia, (61-2) 337-3371, fax (61-2) 337-3378.

June 24-25
Universe 95, College Park, Maryland. Contact the ASP, 390 Ashton Ave., San Francisco, CA 94112, (415) 337-1100. ☐

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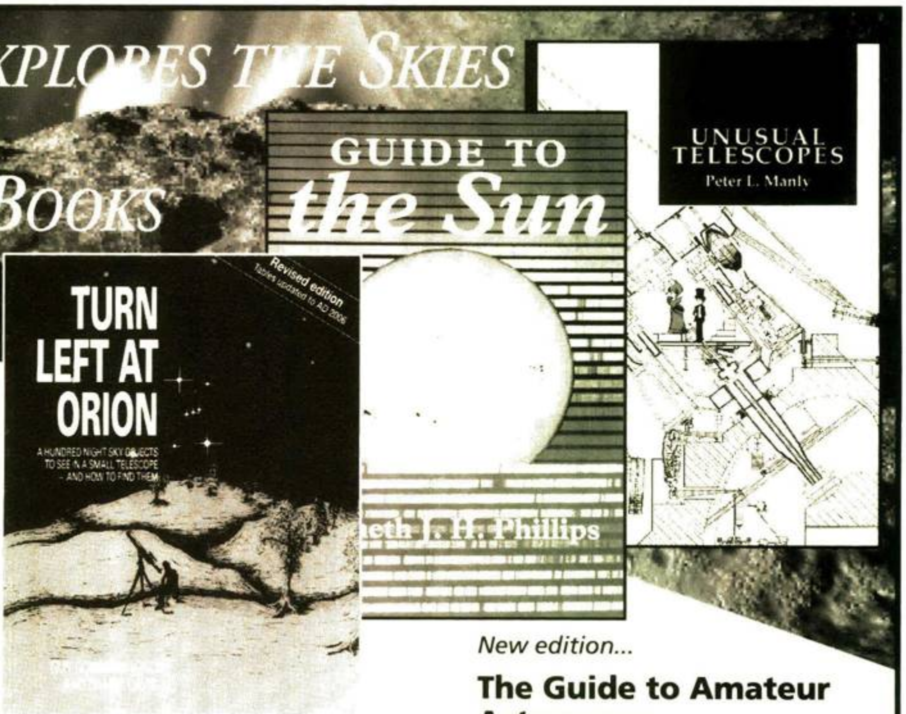
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Shoemaker-Levy 9 (page 48)

"All Eyes on the Comet Crash" by David Bruning, ASTRONOMY, June 1994. Details the breakup of Comet Shoemaker-Levy 9 and what scientists thought would happen when it hit Jupiter.

"Death of a Comet" by David J. Eicher, ASTRONOMY, October 1994. First observations of the comet crash taken by astronomers from around the world.

"Jupiter's Smash Hit" by Robert Burnham, ASTRONOMY, November 1994. Compares observations with pre-crash predictions.

Summer Sky Spectacular (page 66)

Burnham's Celestial Handbook by Robert Burnham, Jr. (Dover, 1978). A three-volume compendium of data, photos, observational tips, and folklore relating to deep-sky objects.

Stars and Galaxies: ASTRONOMY's Guide to Exploring the Cosmos, edited by David J. Eicher (Kalmbach, 1992). A compilation of deep-sky observing articles from ASTRONOMY that includes charts, tables, photographs, and observing tips for finding the objects.

Life in the Fast Lane (page 76)

"Selecting the Right Slide Film" by Alan Dyer, ASTRONOMY, October 1992. An astrophoto test report on all slide films from ISO 25 to ISO 1600 commonly available in 1992 in North America. ScotchChrome 400 was the winner in the high-speed category.

p. 66: Michael Stecker, 8-inch f/4 reflector, Fuji Super HG 400 film, composite of two 45-minute exposures; **p. 67, top:** Preston Scott Justis, 10-inch f/6 reflector, hypersensitized Tech Pan film, 90-minute exposure; **bottom:** Bill and Sally Fletcher, 16-inch f/4.5 reflector, hypersensitized Tech Pan film, composite of 35-minute red, 45-minute blue, and 70-minute green exposures; **p. 68, top:** John P. Gleason, 14-inch SCT at f/11, ISO 400 film, 45-minute exposure; **bottom:** George R. Viscome, 14.5-inch f/6 reflector, 3M 1000 film, 12-minute exposure; **p. 69, top:** Jerry Lodriguss, 5-inch f/8 refractor, hypersensitized Fuji ISO 800 film, 60-minute exposure; **bottom:** Tony and Daphne Hallas, 6-inch refractor, Fuji Super HG 400 film; **p. 70:** Tony and Daphne Hallas, 7-inch f/7 refractor, hypersensitized Fuji Super HG 4000 film, composite of two 60-minute exposures; **p. 71, top:** Scott Hicks, 12.5-inch f/4.8 reflector, Konica 400 film, 30-minute exposure; **bottom:** Jack Newton; **p. 72:** Charles Capen, April 4, 1969; **p. 73, top:** Donald C. Parker; **bottom:** Paul A. Smith and Matthew J. Boulton; **p. 74:** Ronald Royer, September 9, 10, and 11, 1990; **p. 75:** Edwin Faughn, 10-inch f/10 SCT, January 17, 1991; **p. 76-81:** astrophotos by Alan Dyer; **p. 76:** 8-minute exposure with a 105mm lens at f/2 on Ektachrome P1600 processed at ISO 1600; **p. 78:** prime focus shots taken with a 4-inch f/4.5 apochromatic refractor using 18- and 35-minute exposures on Fuji Provia 1600 (top), Ektachrome P1600 (middle), and ScotchChrome 400 (bottom), all processed at ISO 800 and ISO 1600; **p. 79:** piggyback shots taken with a 105mm lens at f/2.5, 4- and 8-minute exposures on Fuji Provia 1600 (top) and Ektachrome P1600 (middle) and 2- and 4-minute exposures on ScotchChrome 400 (bottom), all processed at ISO 800 and ISO 1600; **p. 80, top:** 30-second exposure with a 28mm lens at f/2.8 on Ektachrome P1600 processed at ISO 1600; **bottom:** 20-second exposure with a 50mm lens at f/2.8 on Fuji Provia 1600 processed at ISO 1600; **p. 81:** 25-minute exposure with a 4-inch f/4.5 apochromatic refractor, taken at prime focus on Ektachrome P1600 film processed at ISO 1600; **p. 107:** Alan Dyer, 28mm lens at f/2.8, Ektachrome 100 film, 2-second exposure taken in June 1991 from Ottawa Lake, Wisconsin; **bottom:** Jerry Schad, 24mm lens at f/1.4, Ektachrome P1600 film pushed to ISO 3200, 20-second exposure taken December 14, 1994, in California's Laguna Mountains; **p. 108, top:** Luke Dodd, 4.8-inch f/8.5 refractor, hypersensitized Fuji 400 film, 40-minute exposure; **middle:** Dan Folz, 70mm refractor at f/16, Fuji Super HG 100 film, composite of 27 images taken between 10:20 a.m. and 3:50 p.m. EDT on May 10, 1994, from Rantoul, Illinois; **bottom:** James R. Foster, 14-inch SCT at f/11, hypersensitized Fuji Super HG 400 film, composite of 100- and 90-minute exposures; **p. 109, top:** Luke Dodd, 105mm lens at f/2.4, hypersensitized Fuji 400 film, composite of two exposures; **bottom:** Gerald Rhemann, 6-inch f/10 refractor, hypersensitized Fuji Super HG 400 film, composite of two 70-minute exposures; **pp. 110-111:** Don Parker, 16-inch f/5 reflector, SpectraSource Lynxx PC CCD camera, taken from December 1, 1994, to January 29, 1995; **p. 112:** Richard Cummins, 28mm lens, Ektachrome *100 film, 9-hour* exposure taken September 3, 1994, in Kofa Wildlife Refuge, Arizona. □

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This section is open to anyone who wants to sell or buy astronomy-related merchandise. **RATES:** $1.25 per word. Minimum 10 words. Prepayment required. All copy is set in standard typography. We do not furnish box numbers. **CLOSING DATE:** Fifth of the month three months before cover date (example: March 5 for June issue). Send your ads to ASTRONOMY, Classifieds, P.O. Box 1612, Waukesha, WI 53187-1612, or call (800) 558-1544, extension 538. MasterCard, VISA, or American Express.

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***Astronomy* (Oct. 1974-1994)** and *Telescope Making* (vols. 1, 2, 4, 6, 9, 14-25); $400, includes shipping. Contact Larry Hammersley, R.R. #2, Box 607, Springville, IN 47462, (812) 279-2695.

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Books and Periodicals Wanted

Manual for a Dynamax 8 telescope made by the Criterion Company (now out of business) of West Hartford, Conneticut. If you have instruction sheets or a copy of the manual, I'd appreciate hearing from you. Contact John D'Ambrosio, 441 Vern Avenue, Lyndhurst, NJ 07071.

***Telescope Making* vols. 12, 13, and 16.** Contact John Armour, P.O. Box 26038, Richmond Mall, Christchurch, New Zealand.

***Webb Society Handbook* #1,** and #4-#7, *Deep Sky* vols. 1-13, and 27, *Uranometria 2000.0* vols. 1 and 2; and issues of *Sky and Telescope* before 1987. All at reasonable prices. Contact Sherry O'Neill, 325 Highland Rd., Pittsburgh, PA 15235-3012.

Communications Wanted

Information on all known or suspected meteor showers with data for research purposes. Attempting to compile complete listing of above, with a view to eliminate discrepancies. Contact Don Simpson, 78 Stratford Avenue, Grangetown, Sunderland, SR2 8RZ, England, 091-567-0151.

Collector desires correspondence with dealers or collectors of early star charts and star atlases from 1500 to 1801. Particularly interested in work by Piccolomini, Gallucci, Bayer, Schiller, Cellarius, Hevelius, Flamsteed, Goldbach, and Bode. Contact Ray Harris, 2111 Wisteria Road, Macungie, PA 18062, (610) 395-8809.

I am interested in the mystery of the lost Chinguetti Mauritania Meteorite and would like to correspond with someone who has been to Mauritania, or has knowledge of the meteorite. Contact Lee Sawyer, HCR 62, Box 56, Mt. Desert, ME 04660.

Miscellaneous For Sale

"Face on Mars" photograph (enlarged); $25 or offers. Weather balloon, 37'-diameter; $100. Meade 90mm telescope with equatorial mount, eyepieces, diagonal; $500. Contact Phil Hopkins, 3411 39th St., Lubbock, TX 79413.

Organization Announcements

Live in Pennsylvania? Tired of trying to see the stars through murky light pollution? If you're serious about saving the stars, please contact me. If other states can pass light pollution legislation, why can't we? Contact P. Edward Murray, 918 Hamilton Drive, Yardley, PA 19067-4302.

The Stratford-upon-Avon Astronomical Society is a recently formed organization in the United Kingdom. We welcome visitors on a regular basis, exchanging various cultural activities. Eventually we hope to meet our colleagues overseas. If you have an interest, drop us a line. Contact John Harrison, Secretary, Stratford-upon-Avon Astronomical Society, 14 Avon Crescent, Stratford-upon-Avon, Warwickshire, CV37 7EU, United Kingdom.

Kettering and District Amateur Astronomers Society meets at 7:30 p.m. on the first and third Tuesday of each month at the Quaker Meeting Hall, Northall Street, Kettering, England. Correspondence invited from other societies. Contact Steve Williams, 120 Brickhill Road, Wellingborough, Northants, NN8 3JP, England.

Interested in astronomy? Live in Peru? We have an astronomy club for you! Ours meets regularly and organizes many activities. Ephemeris and events bulletin coming soon. Contact Luis Miguel, Urbina 354639 Peru; Julio Chaname, Lima 637887 Peru; or Javier Quino, Lima 361348 Peru.

The Astronomical Society of Harrisburg meets at 7:30 p.m. on the second Monday of each month at the Museum of Scientific Discovery October through April and at the Naylor Observatory near Lewisberry May through September. Contact Edward L. Naylor, (717) 938-6041.

Astronomical Society of Southern New England meets every last Saturday of the month with public viewing at Carpenter Museum, Rehoboth, Massachusetts. Contact Ken Conca, (401) 351-5676.

Attention Toronto-area astronomers. An observing group is now forming in Markham, Unionville, Stouffville, Newmarket, Aurora, and surrounding areas. If you are interested contact Rob Underhill, (905) 471-5996 or Peter Smirlies, (905) 895-1267.

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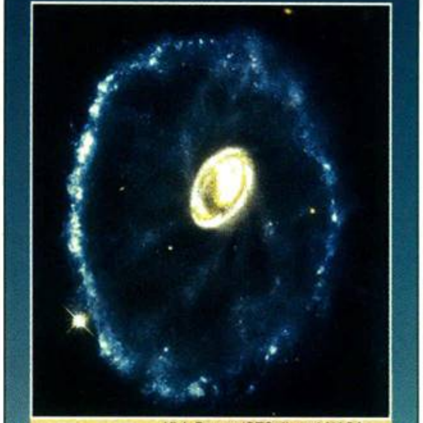
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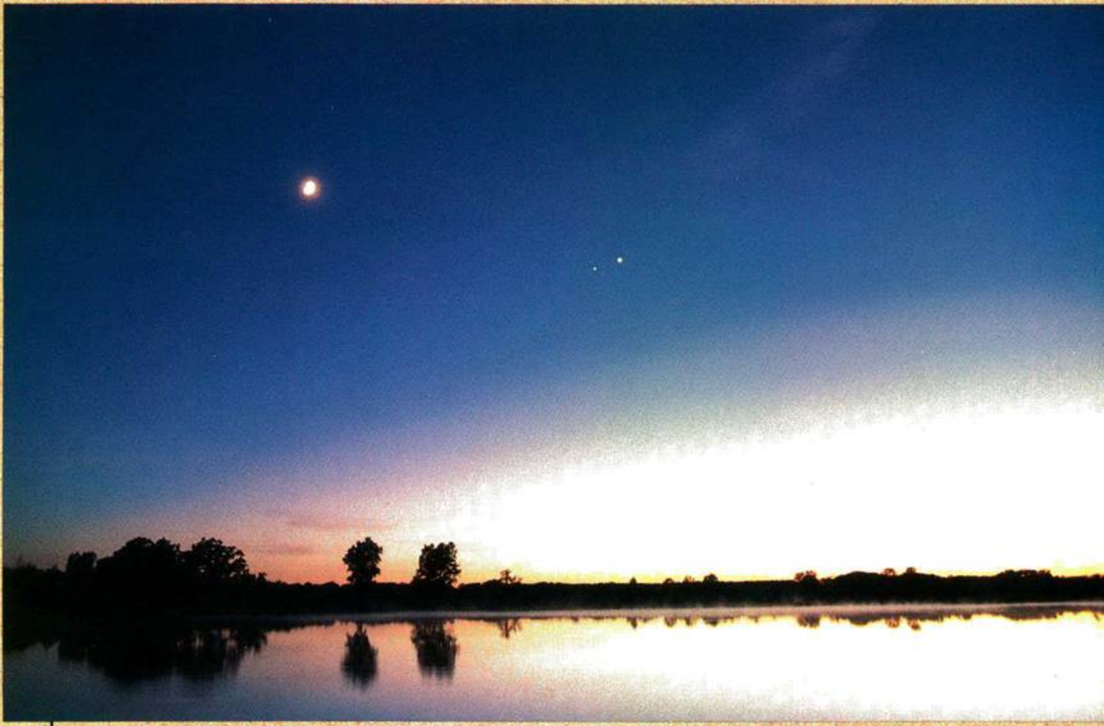
Nine in One Night

Marathon observing sessions are typically the province of deep-sky observers, as evidenced by the many Messier Marathons held each year. Such events are contests in which sharp-eyed skywatchers attempt to spot all 107 Messier objects in a single night. But Dennis Tye of San Francisco, California, believes planetary observers ought to try marathons as well. In fact he attempted his first planetary observing marathon on June 21, 1993, from Fremont Peak, California and used the 30-inch telescope there to accomplish it. The goal? Observe nine planets in one night.

"The first one is free," says Tye — "just look between your toes and you'll spot Earth." The other eight require a bit more planning. Four of the planets — Venus, Mars, Jupiter, and Saturn — are easily visible during most of any given year, although more surface detail can be glimpsed on an outer planet near opposition. Mercury alternates between morning and evening skies about every two months. "For those of you who prefer not to get up at dawn," says Tye, "that means Mercury is an evening star at four-month intervals." Uranus, Neptune, and Pluto are moving slowly near some constellation boundaries, placing them in the summertime constellations of Libra, Ophiuchus, and Sagittarius.

Tye accomplished the task with ease. "Right after dusk I spotted Mercury nearly 20° above the western horizon. I next found Mars in



The Moon, Venus, Mars, and Jupiter over Ottawa Lake, Wisconsin

by Alan Dyer
(28mm lens at f/2.8, Ektachrome 100 film, 2-second exposure taken in June 1991)

A –3-Magnitude Geminid Meteor Flashes Over the Horizon

by Jerry Schad
(24mm lens at f/1.4, Ektachrome P1600 film pushed to ISO 3200, 20-second exposure taken December 14, 1994, in California's Laguna Mountains)

Leo, close to the bright star Regulus. Jupiter, in Virgo, was next. It is always a beautiful sight and was especially good that night as two moons were transiting the Jovian disk." Tye next tackled Pluto, which he found using the map in the May 1993 ASTRONOMY. "It's difficult to know you've seen the right point of light until you watch it move over a couple of days," Tye says.

The ultrafaint challenge aside, Tye next observed Uranus and Neptune, which once located were "easy to distinguish from the surrounding stars by their greenish and blue-green color and tiny disks." With most of the other planets done, Tye set his sights on Saturn, which rose after midnight in Aquarius. Taking advantage of pinpoint seeing, Tye cranked up the 30-inch scope to 400x and saw Cassini's Division sharply, some cloud bands on the planet's globe, and the shadow of the rings.

After observing Saturn for a long time, soaking in detail, Tye faced a new challenge. Fatigue began to set in, and the chill of the night air took its toll.

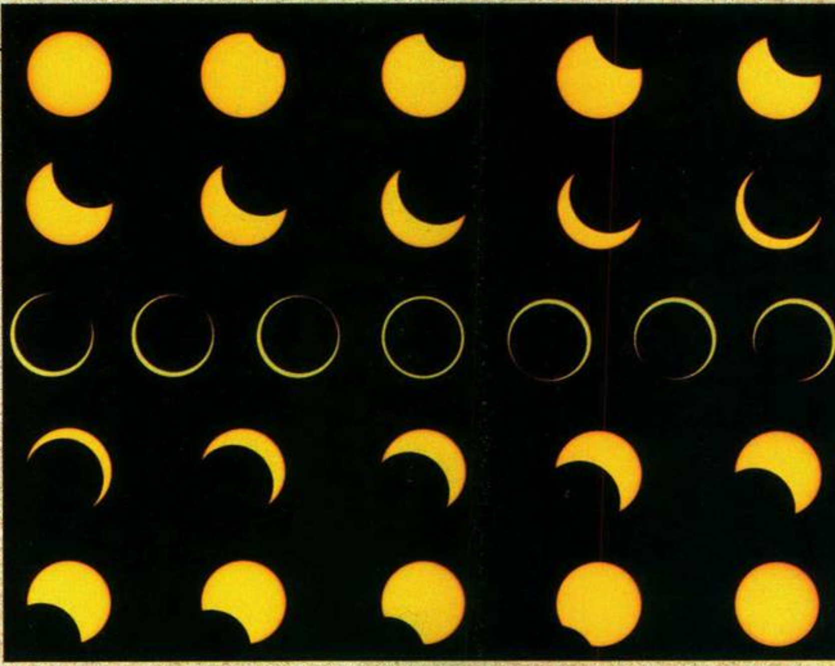
"Now it was just a matter of staying awake until 4 a.m. until Venus rose in the east," he says. "I stopped down the telescope to one-fourth of its aperture, or else it would have been like staring at a spotlight."

Tye stayed awake and recorded Venus, making it nine planets in one night. "It's really something to remember," he says. "I recommend it to everyone as something they should do at least once." ☐

ASTRONOMY wants to hear about your observations of the sky. Send reports, sketches, and photographs to David J. Eicher, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187. Please label each photo with name, address, and social security number. You may send written reports via the Internet to: 72000.2704@CompuServe.com.

Globular Cluster Omega Centauri

by Luke Dodd (4.8-inch f/8.5 refractor, hypersensitized Fuji 400 film, 40-minute exposure)



The Annular Eclipse of May 10, 1994

by Dan Folz (70mm refractor at f/16, Fuji Super HG 100 film, composite of 27 images taken between 10:20 a.m. and 3:50 p.m. CDT on May 10, 1994, from Rantoul, Illinois)

Local Group Galaxy IC 10

by James R. Foster (14-inch SCT at f/11, hypersensitized Fuji Super HG 400 film, composite of 100- and 90-minute exposures)

The Large and Small Magellanic Clouds

by Luke Dodd
(105mm lens at f/2.4, hypersensitized Fuji 400 film, composite of two exposures)

The Pleiades

by Gerald Rhemann
(6-inch f/10 refractor, hypersensitized Fuji Super HG 400 film, composite of two 70-minute exposures)

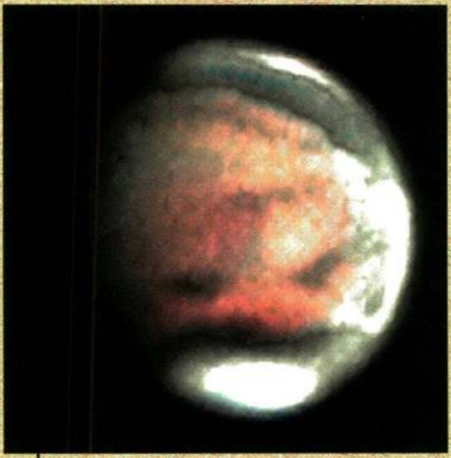
The Red Planet Spins into View

Mars has grown in our sky over the past months and reached opposition, a point opposite the Sun in the sky, on February 11/12, 1995. At that time the planet shone brilliantly at magnitude –1.2 and measured 13.9" across, providing the best opportunity for viewing Mars until 1997. (By now, the planet measures only 8" across.)

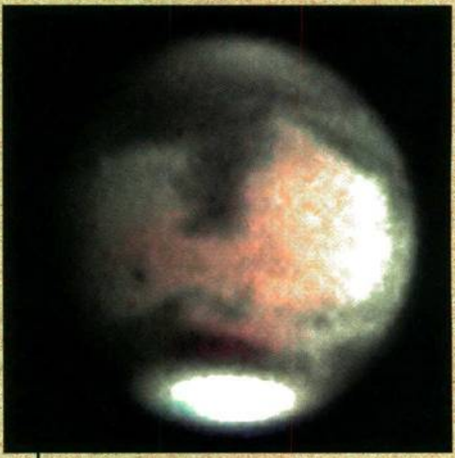
Florida astroimager Don Parker created this view of the face of Mars from December 1, 1994, to January 29, 1995, using his 16-inch f/5 reflector at his observatory in Coral Gables. Parker achieved such outstanding sharpness in the images by using a SpectraSource Lynxx PC CCD camera and shooting the planet during moments of steady seeing.

The results depict a Red Planet replete with morning fog banks, polar hazes, and a swelled northern polar cap. Compare the images with a Martian map like that provided on p. 74 of "Discover the Red Planet," January 1995. South is at top in all images.

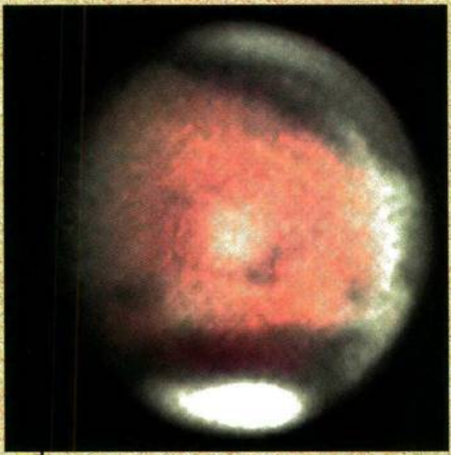
The December 30 image, with its central meridian of 290°, shows the prominent dark feature Syrtis Major and Utopia. The bright white basin Elysium stands out in the January 2 and 4 images. Clouds over Martian volcanos such as Olympus Mons can be seen in the January 12 and 13 images. □



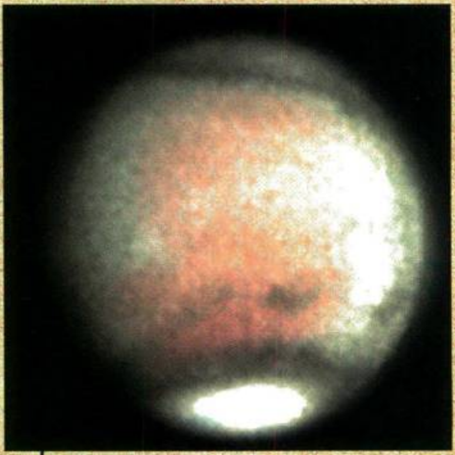
Dec. 1, 1994 **8:31 UT**
Central Meridian = 194°



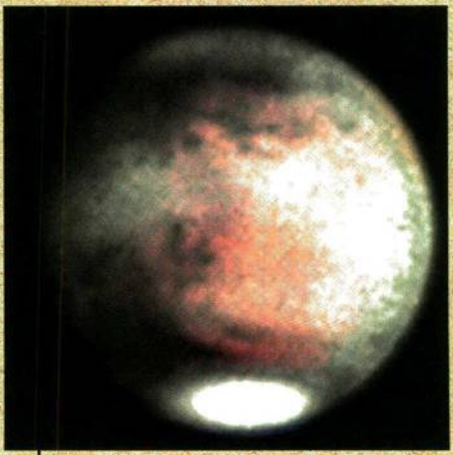
Dec. 30 **8:54 UT**
CM = 290°



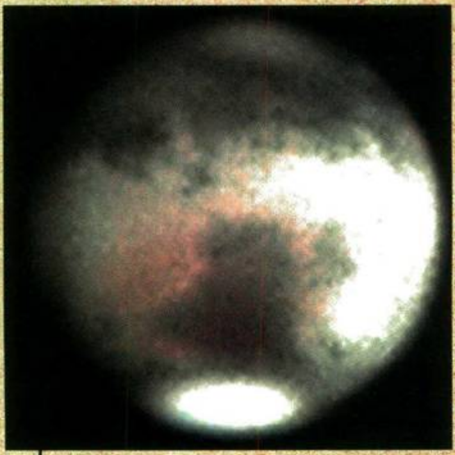
Jan. 4 **6:43 UT**
CM = 212°



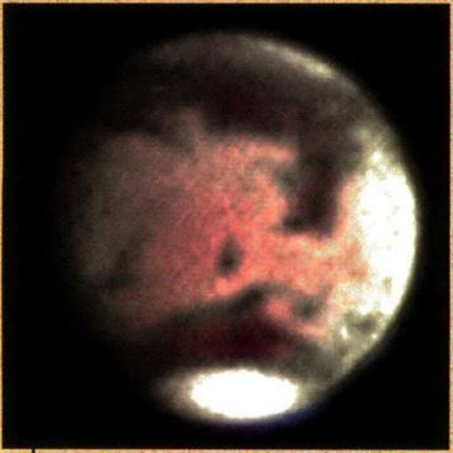
Jan. 12 **8:04 UT**
CM = 160°



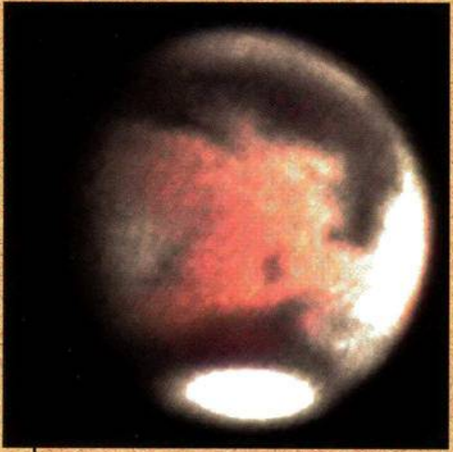
Jan. 18 **5:36 UT**
CM = 70°



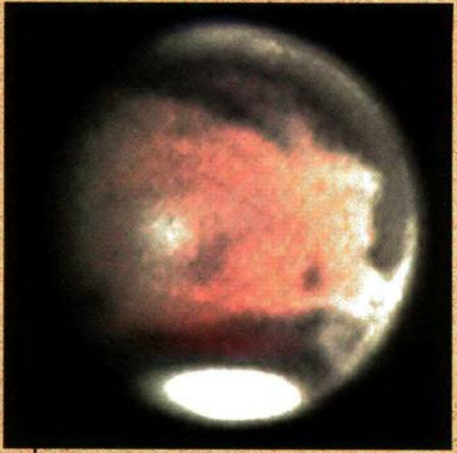
Jan. 23 **5:35 UT**
CM = 26°



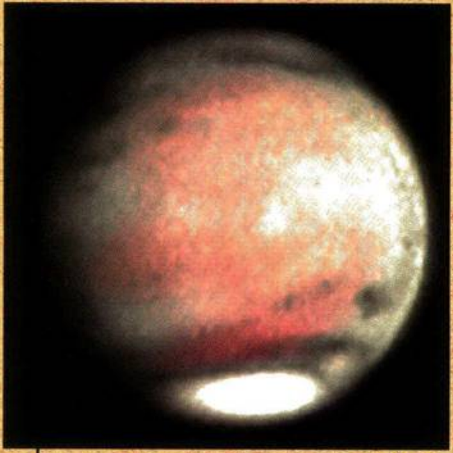
Dec. 31 **7:34 UT**
CM = 261°



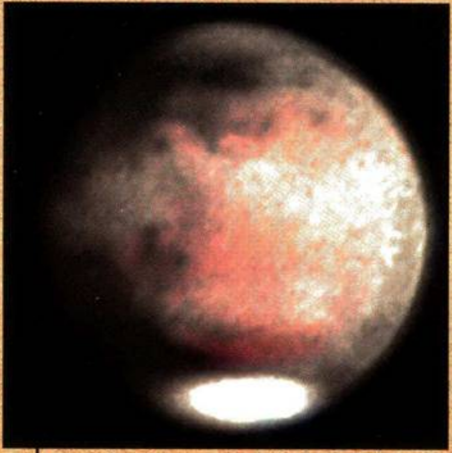
Jan. 1, 1995 **7:14 UT**
CM = 247°



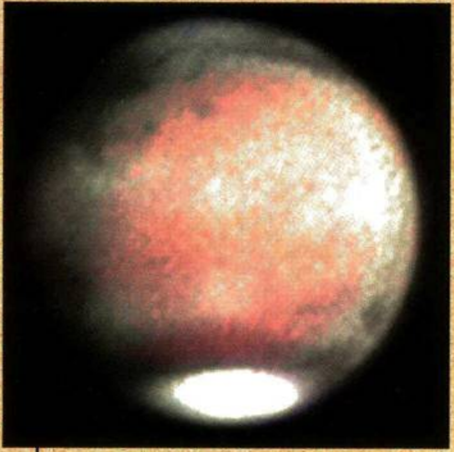
Jan. 2 **6:42 UT**
CM = 230°



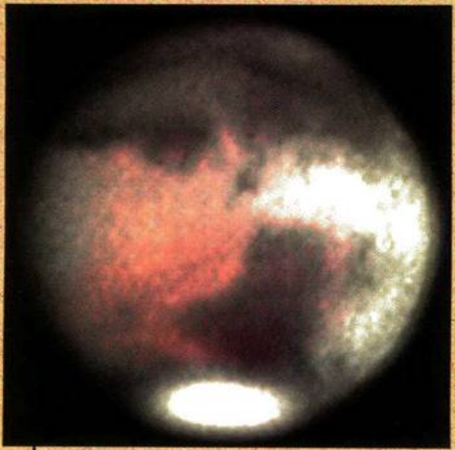
Jan. 13 **6:07 UT**
CM = 123°



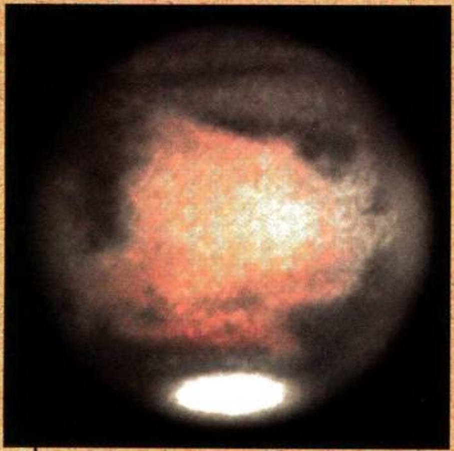
Jan. 17 **5:33 UT**
CM = 79°



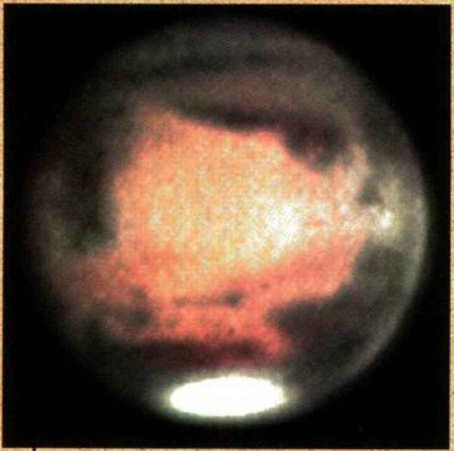
Jan. 17 **7:31 UT**
CM = 107°



Jan. 25 **5:43 UT**
CM = 10°



Jan. 28 **4:39 UT**
CM = 328°



Jan. 29 **5:26 UT**
CM = 331°

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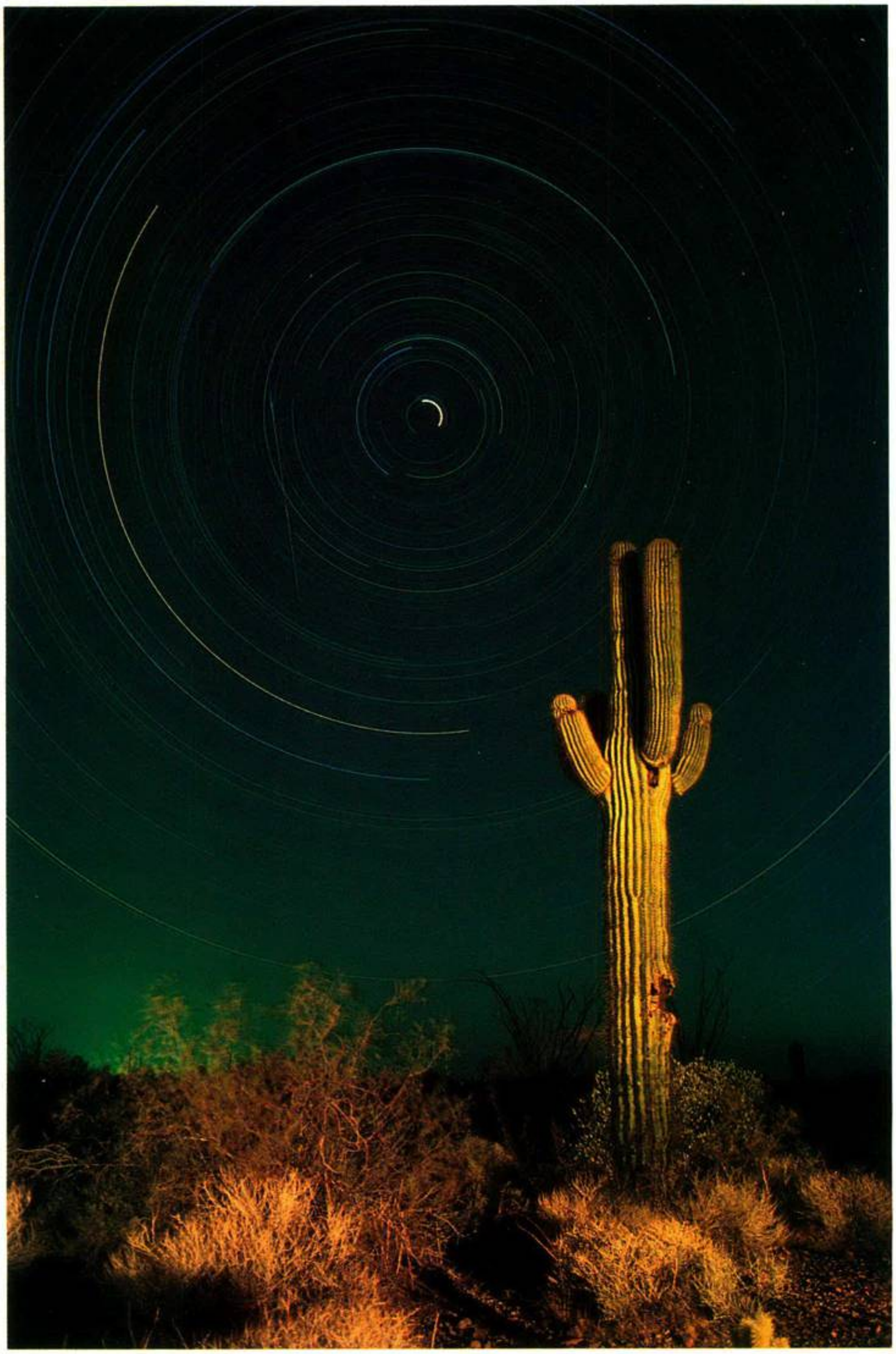

Star Trails over Arizona's Kofa Wildlife Refuge

by Richard Cummins
(28mm lens, Ektachrome 100 film, 9-hour exposure taken September 3, 1994)

"Capturing the meteor startled me, as it flashed across the sky shortly after I started the exposure," says Cummins, a resident of Hemet, California. "During the exposure I illuminated the cactus using a flashlight."

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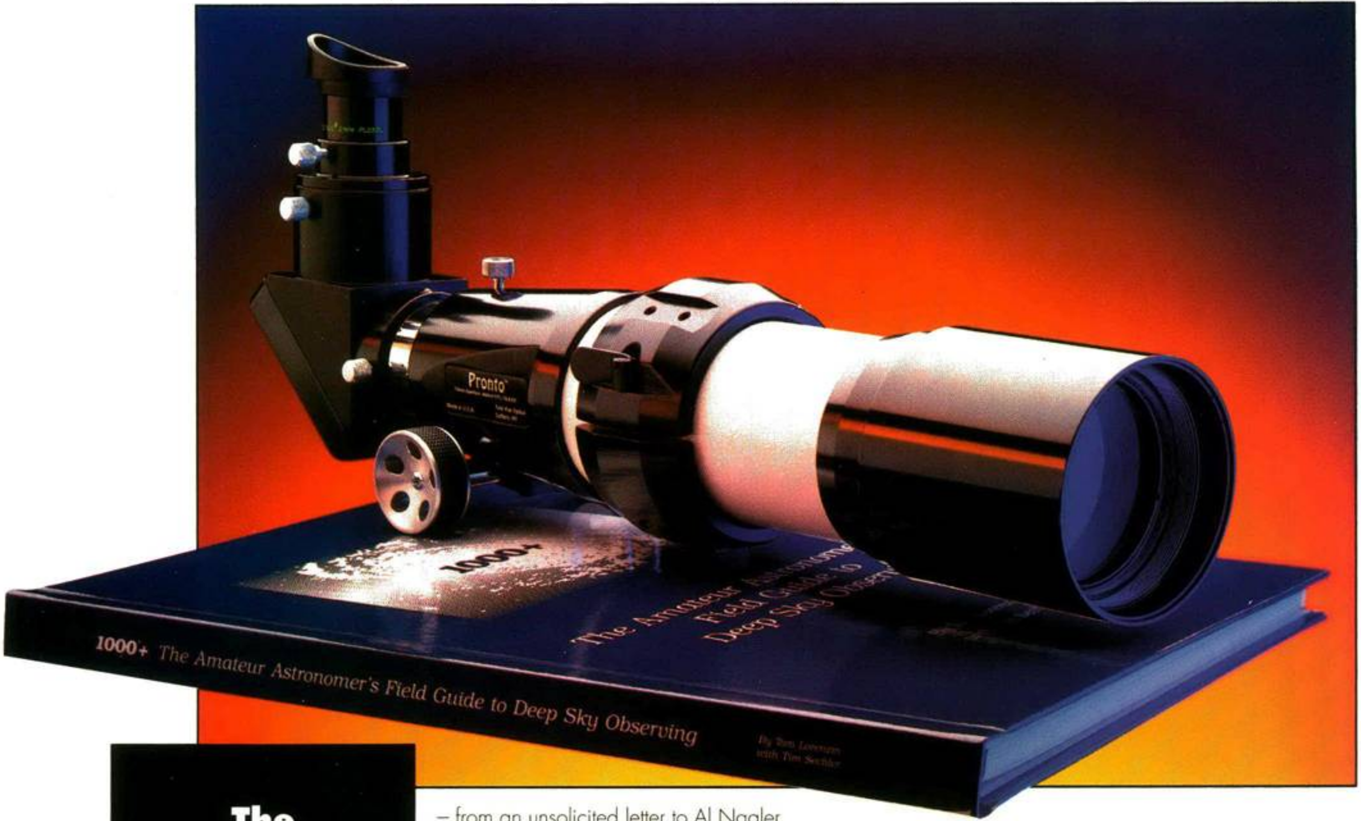
Pronto: 70mm Ap., 480mm F.L., f/6.8 E.D. doublet, 2" diagonal, 21mm Plössl, adapter, mount ring, shoulder bag all std.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Pronto photo of Eta Carina by Ralph Sieger

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Astronomy Magazine in a recent review said, "The C5 I tested contained superb optics. At high powers, stars exhibited a clearly defined Airy disk surrounded by a bright first diffraction ring and several successively fainter outer rings. This was a telescope that demonstrated how well Schmidt-Cassegrain optics can perform and met **Celestron's** promise of diffraction-limited optics."

In a recent review by *Sky & Telescope*, the following is noted, "the optical correction and factory collimation were excellent. At high magnification, bright stars were surrounded by a classic set of diffraction rings."

The C5 is truly a multipurpose instrument – an astronomical telescope, a spotting scope and a 1250mm f/10 telephoto lens. Great for terrestrial applications such as bird watching, nature study, vistas from view homes or as a superb 1250mm telephoto lens. It even focuses as close as 20'.

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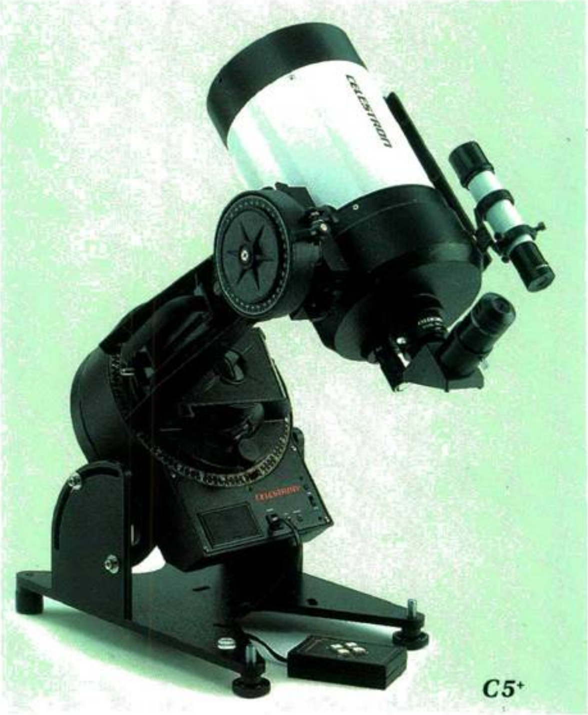

C5⁺

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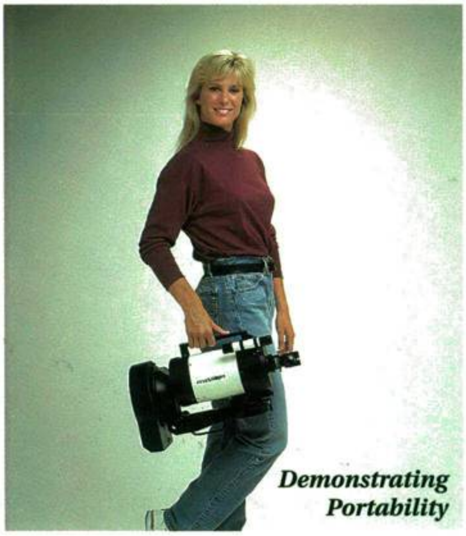

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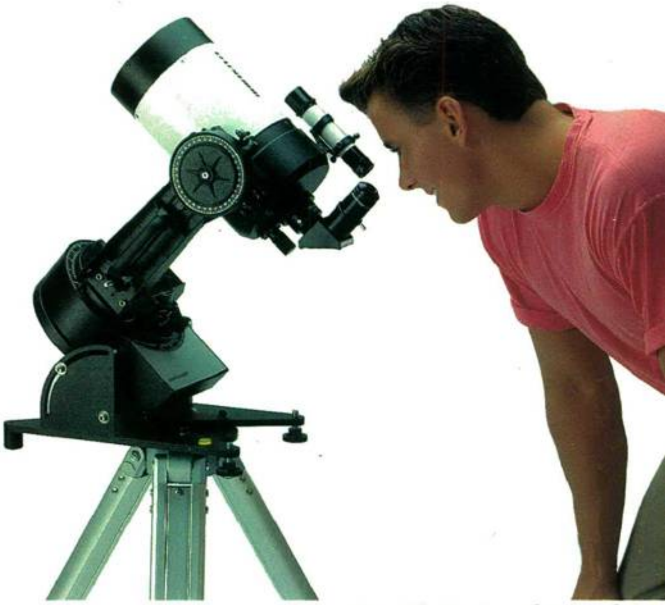

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